

WYOMING

SOUTH DAKOTA

# *Drought and the Climate of the Ogallala Aquifer*

Nolan J. Doesken

Colorado Climate Center

Colorado State University

Presented at Ogallala Symposium, Wray, Colorado

February 20, 2006

Prepared by Odie Bliss

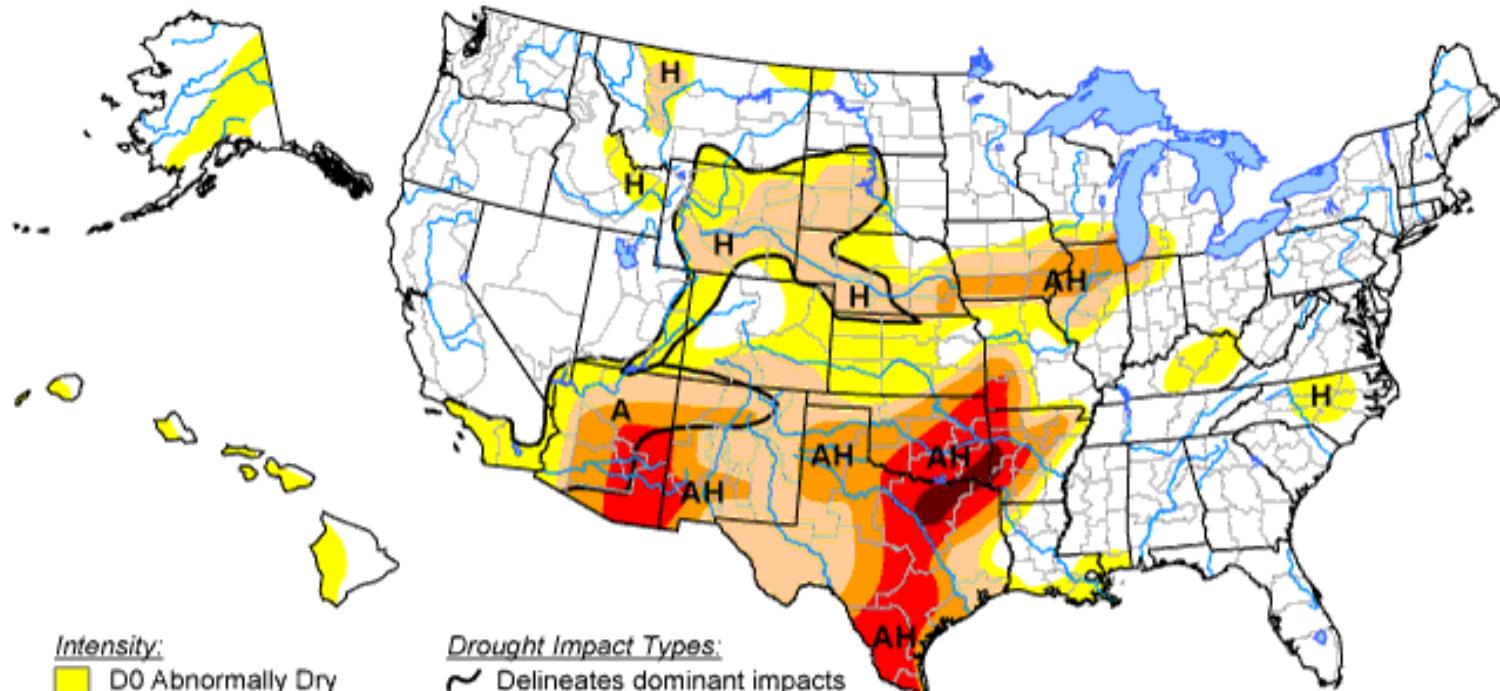


Colorado State  
University  
*Knowledge to Go Places*

# Drought Monitor Map

## U.S. Drought Monitor

February 14, 2006  
Valid 7 a.m. EST



Intensity:

- [Yellow square] D0 Abnormally Dry
- [Light orange square] D1 Drought - Moderate
- [Orange square] D2 Drought - Severe
- [Red square] D3 Drought - Extreme
- [Dark red square] D4 Drought - Exceptional

Drought Impact Types:

- ~ Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)

The Drought Monitor focuses on broad-scale conditions.  
Local conditions may vary. See accompanying text summary  
for forecast statements.

<http://drought.unl.edu/dm>



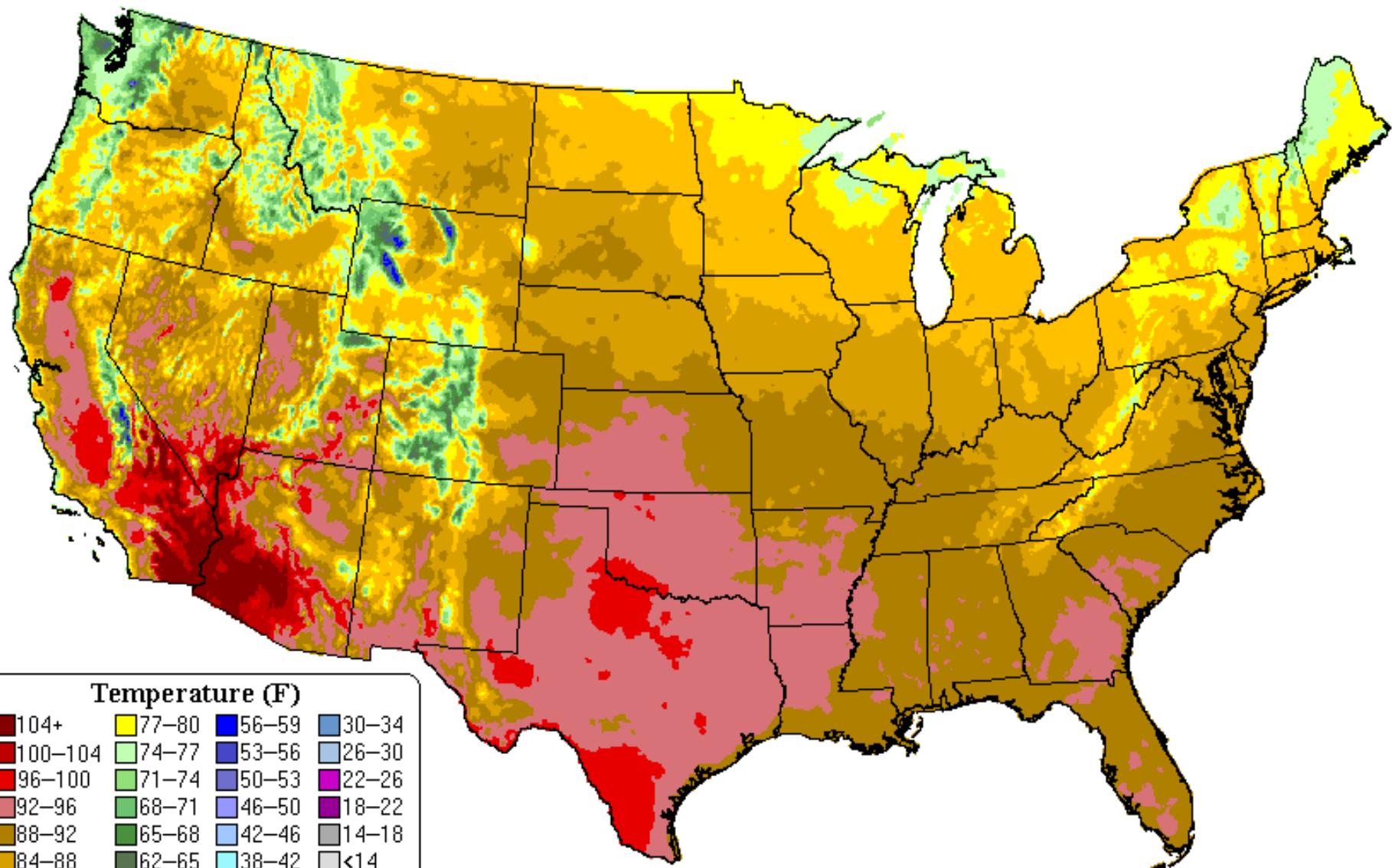
Released Thursday, February 16, 2006  
Author: David Miskus, JAWF/CPC/NOAA

The background of the image is a stunning sunset or sunrise. The sky is filled with thick, textured clouds that are bathed in warm, golden-orange light. The colors transition from deep orange at the horizon to a darker, reddish-pink in the upper layers of clouds. In the distance, dark silhouettes of hills or mountains are visible against the bright sky.

But what does this mean?

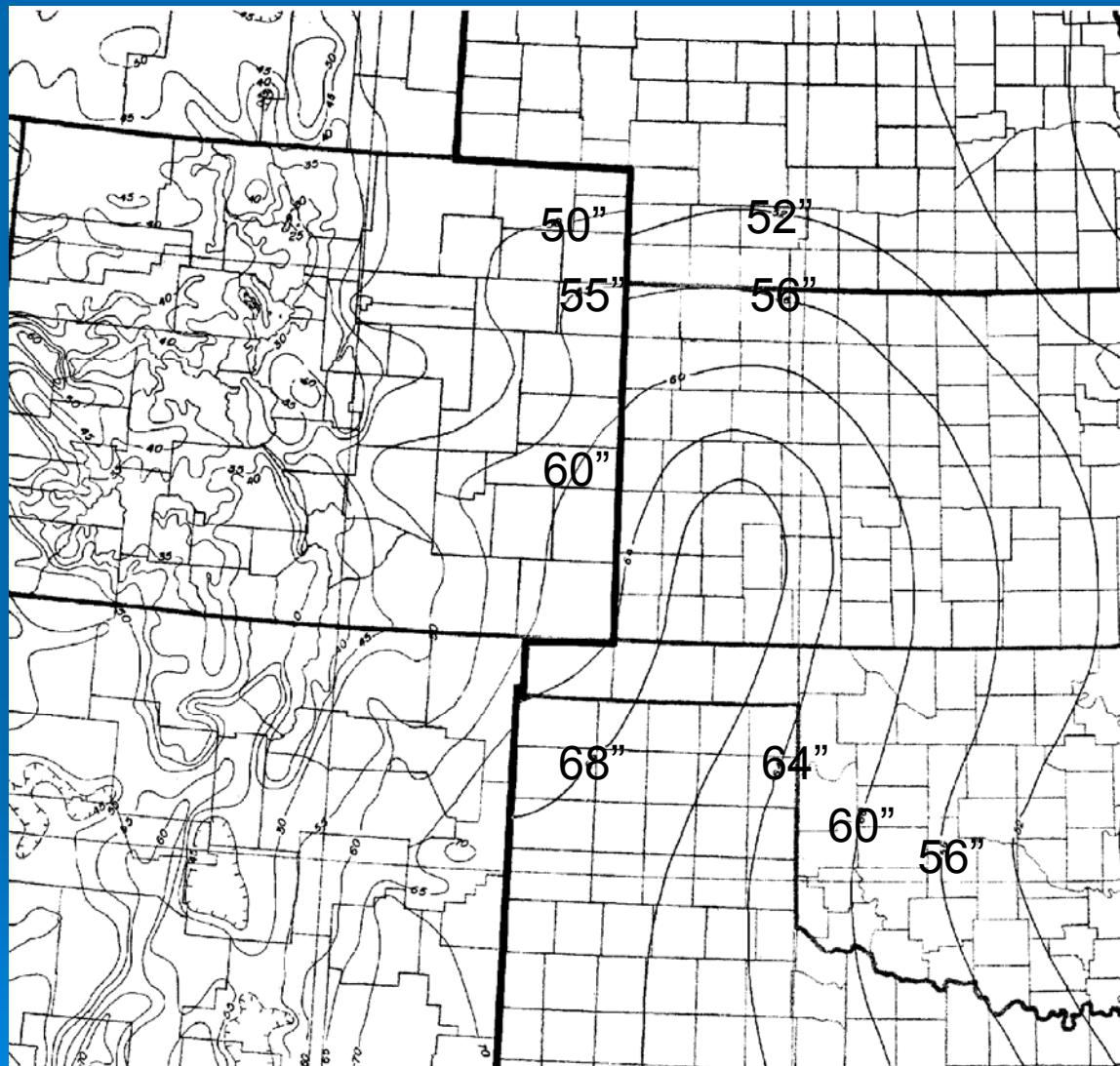
We need some  
perspective.

## Maximum Temperature: July Climatology (1971–2000)



Copyright (c) 2004, Spatial Climate Analysis Service, Oregon State University  
<http://www.scs.oregonstate.edu/prism> – Map created Feb 20 2004

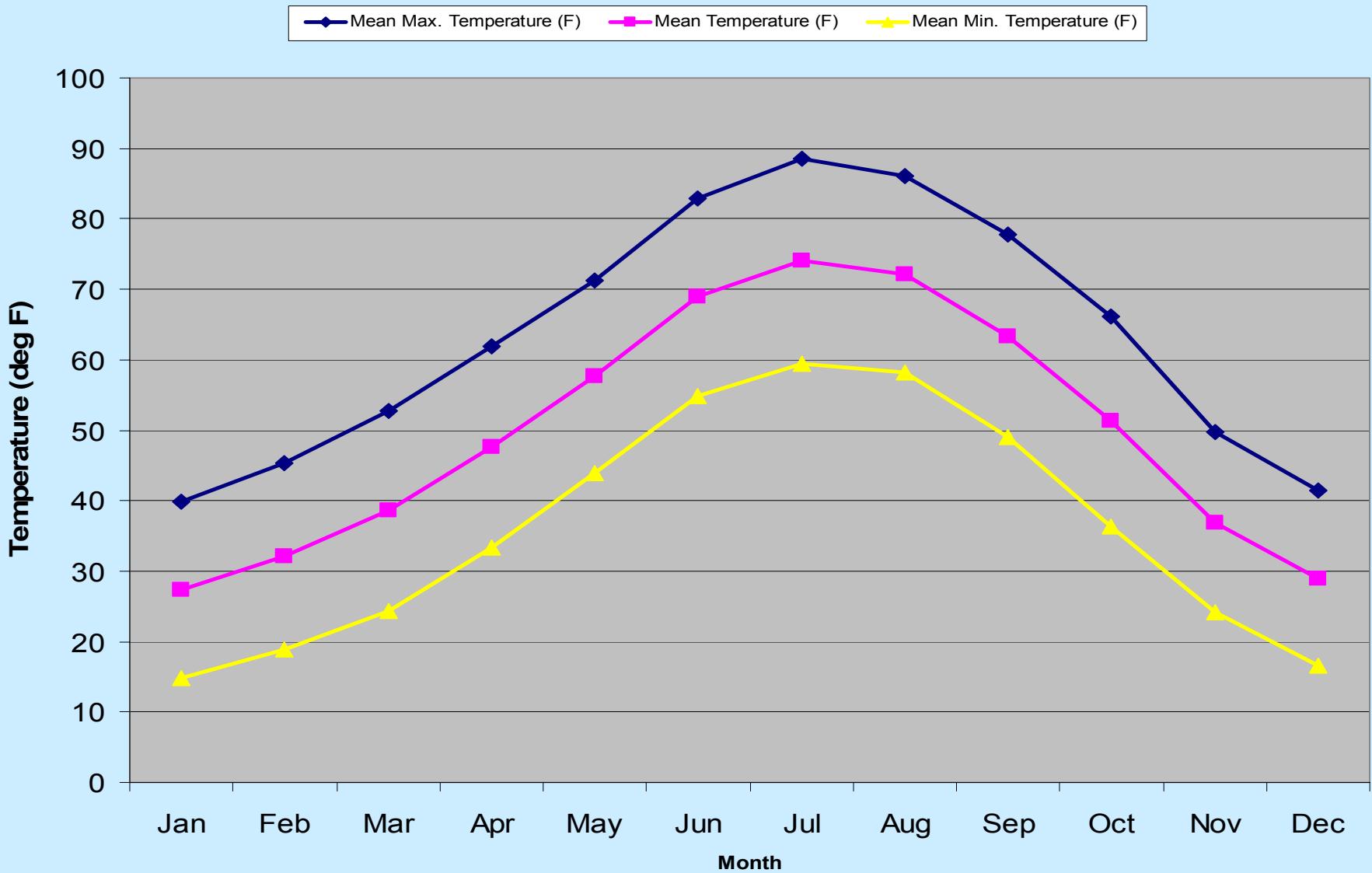
# Class A Pan Evaporation (May-Oct)



From NOAA Tech Report NWS 33

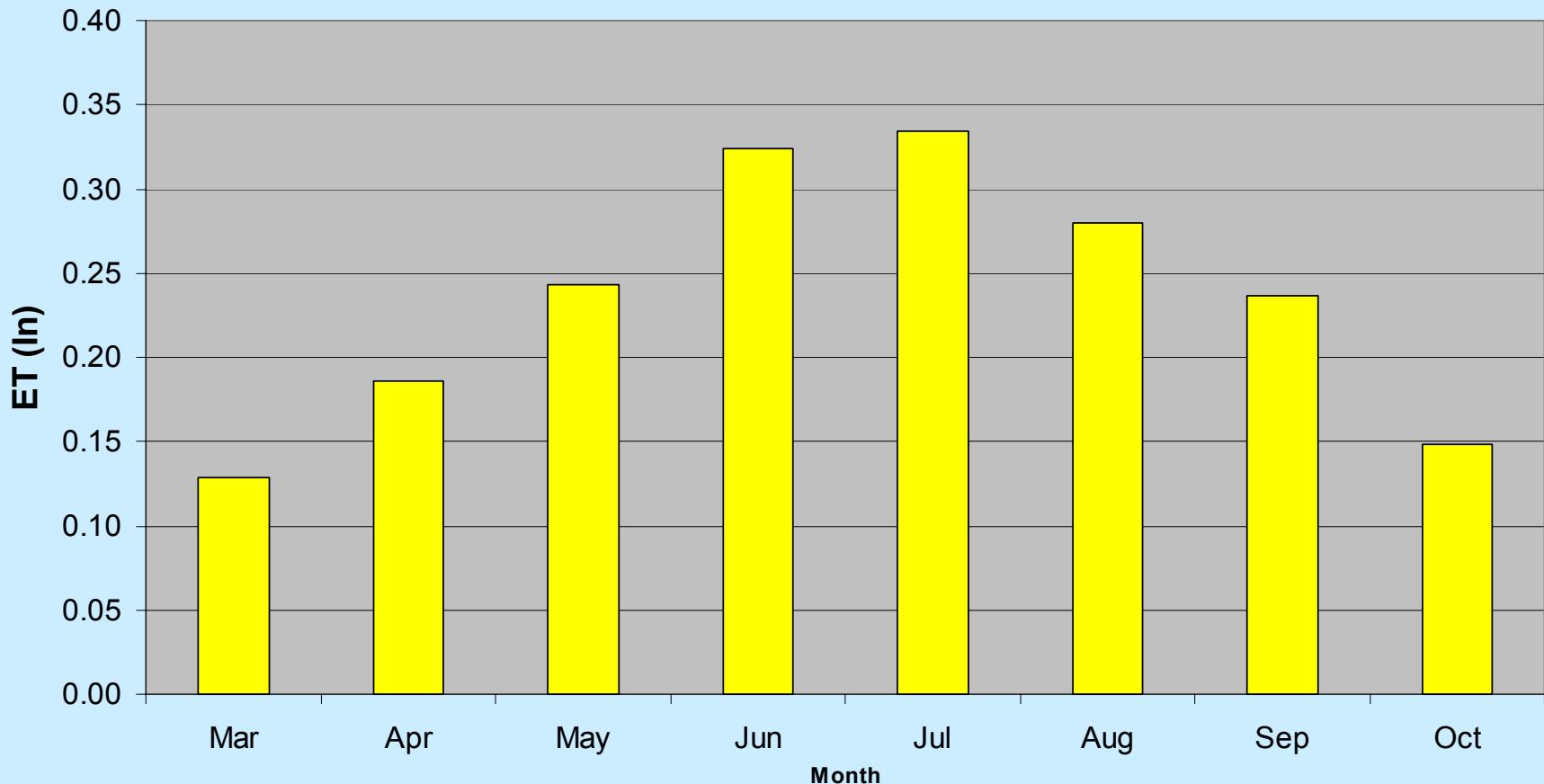
# Burlington Temperatures

## Burlington, CO, Average Temperatures



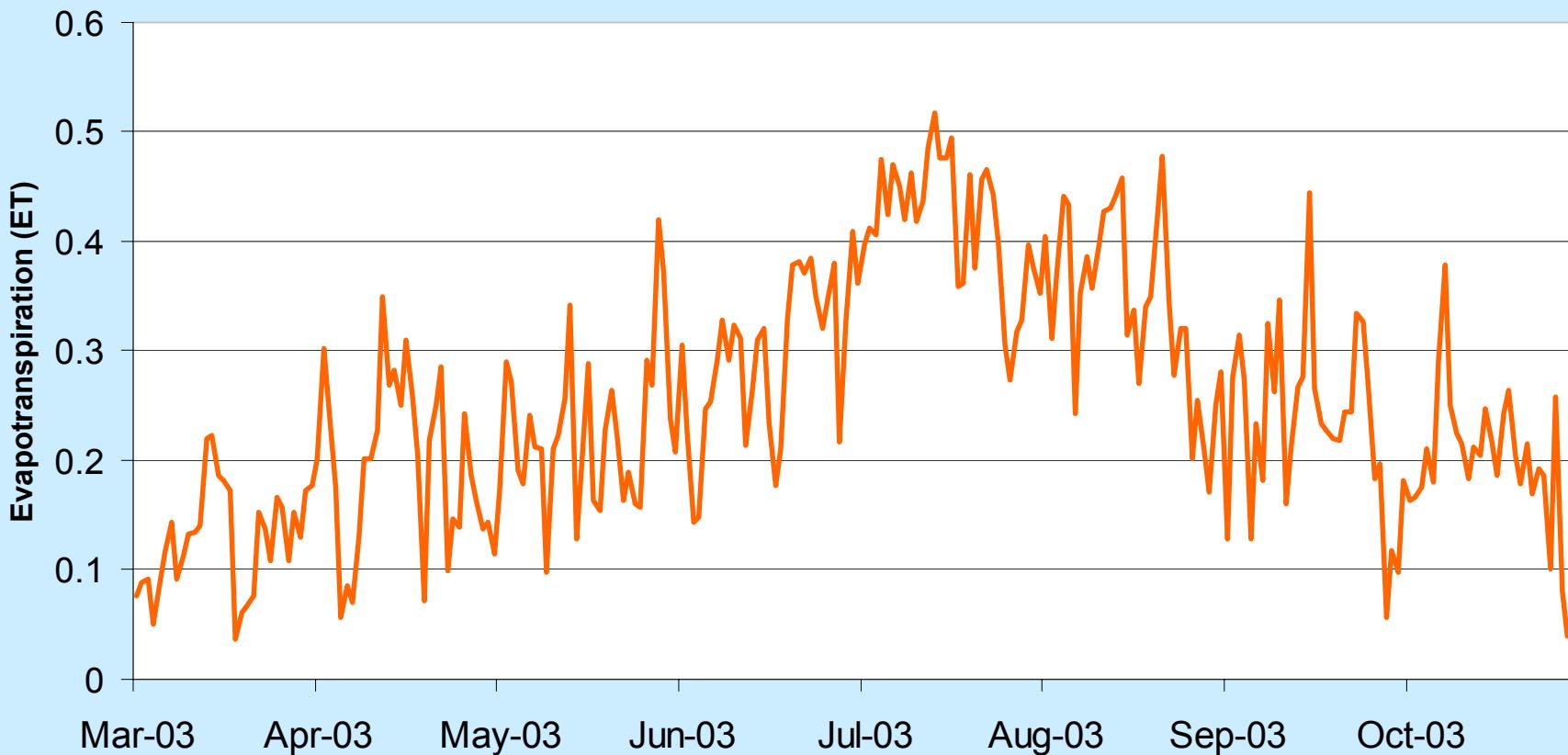
# Idalia CoAgMet Reference Evapotranspiration (ET)

Idalia Average Reference Evapotranspiration (ET) Values



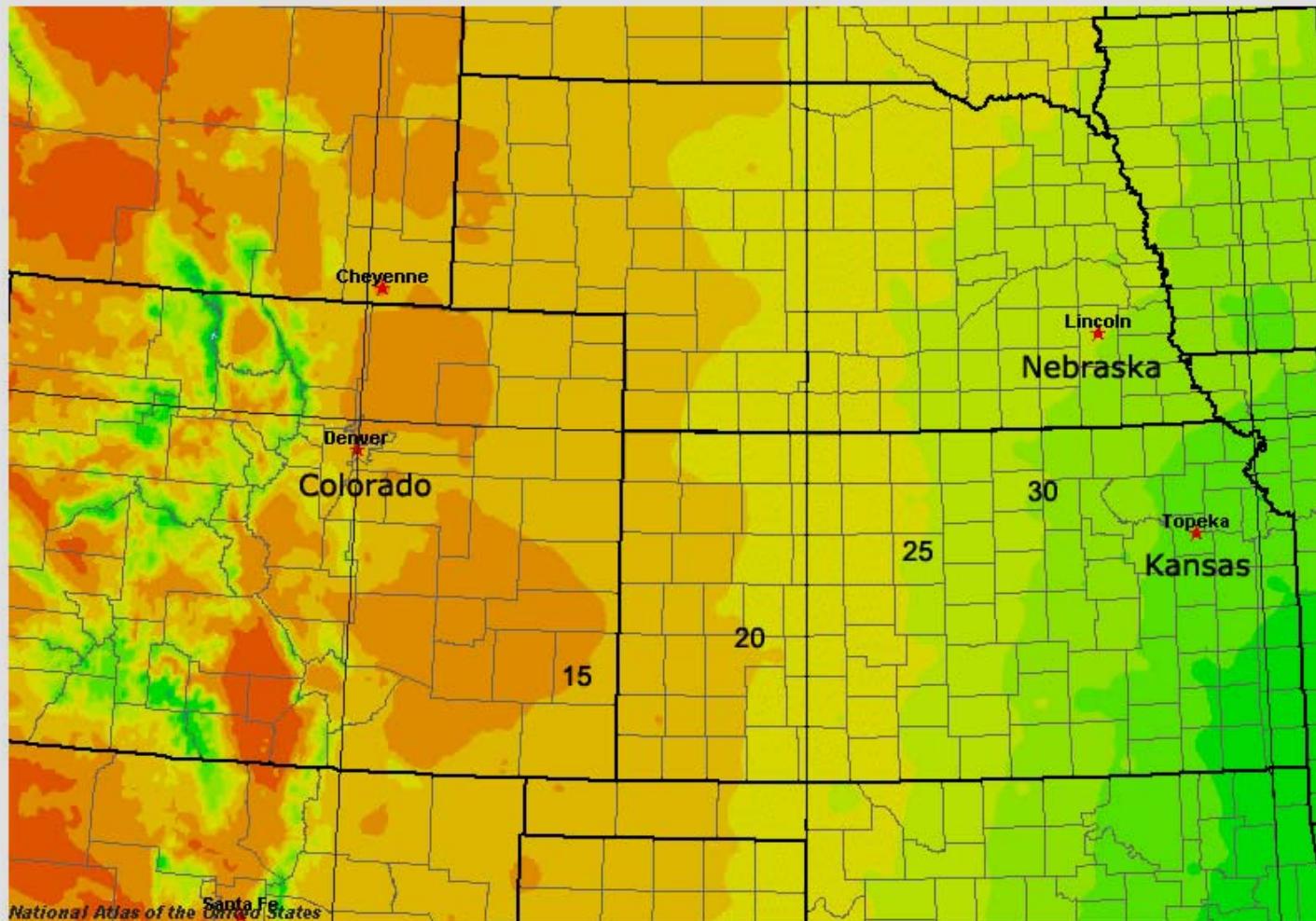
# Reference Evapotranspiration (ET)

Kirk, Colorado,  
Reference Evapotranspiration (ET) for 2003



# COLORADO, KANSAS AND NEBRASKA

## AVERAGE ANNUAL PRECIPITATION, 1961-1990

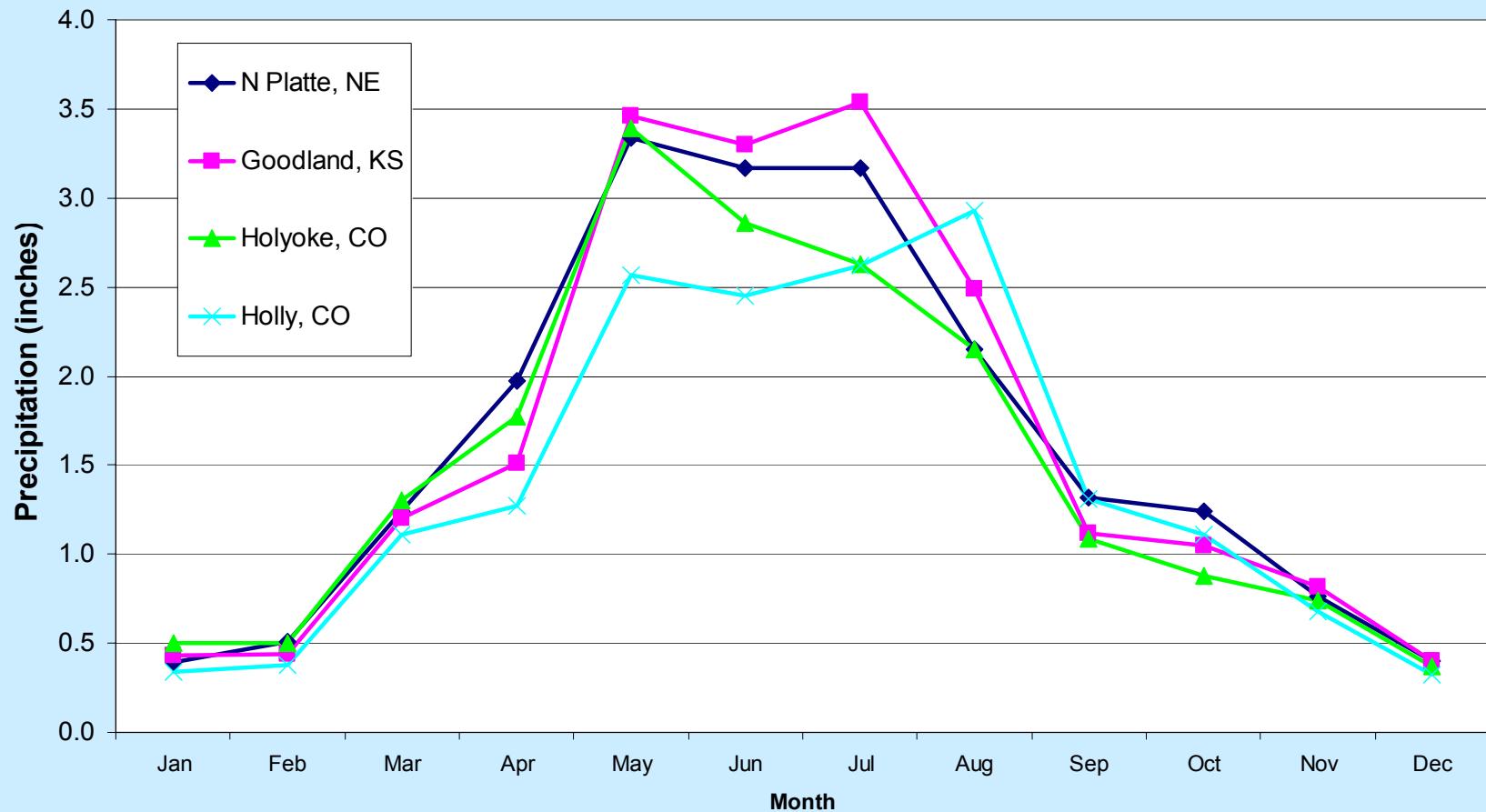


National Atlas of the United States

National Atlas of the United States, <http://nationalatlas.gov>

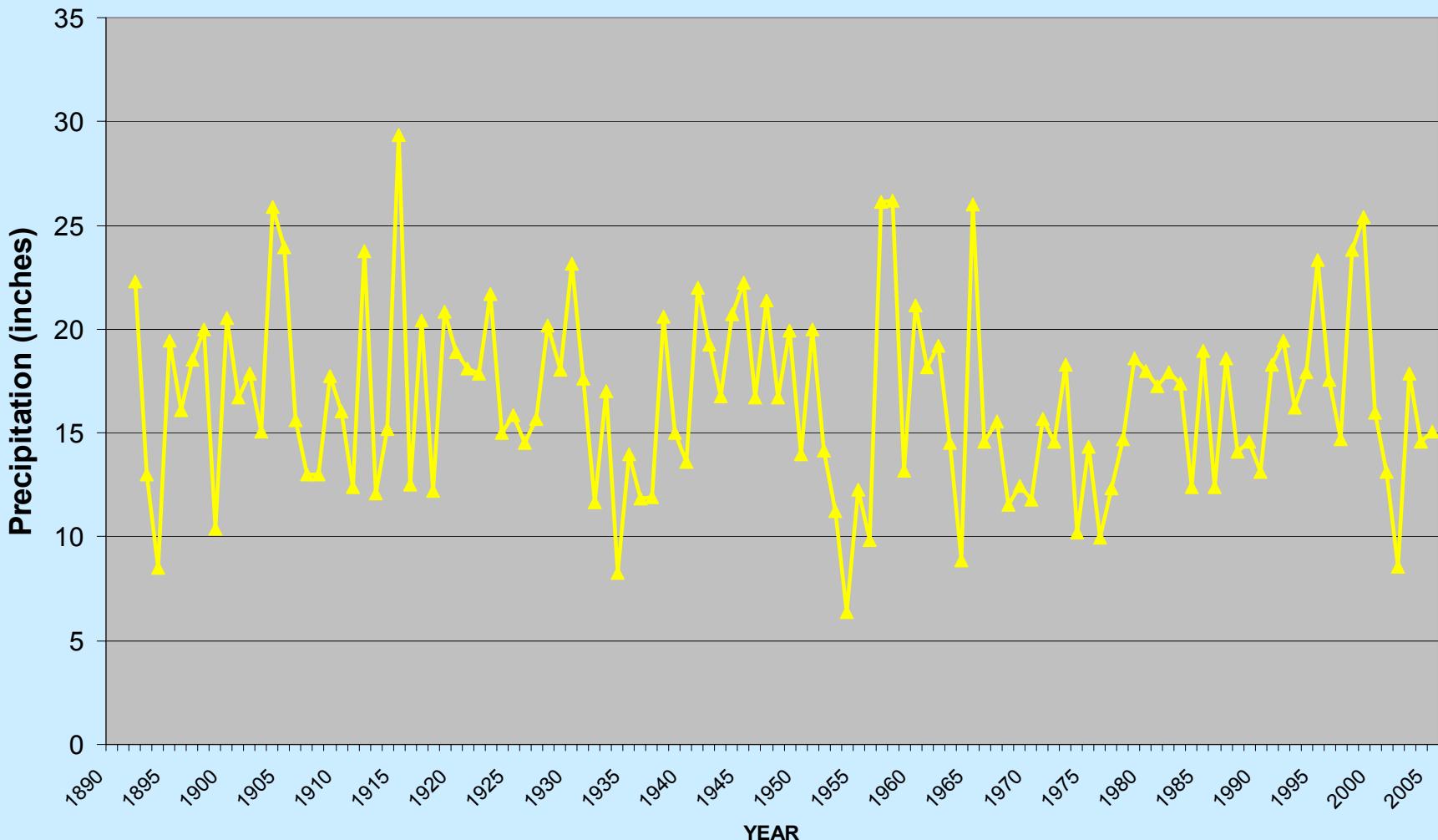
# Monthly Average Precipitation for selected stations in the Ogallala Aquifer

Ogallala Aquifer  
Monthly Average Precipitation (1971-2000)

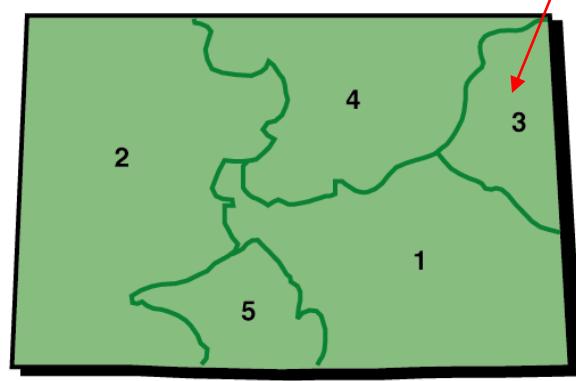
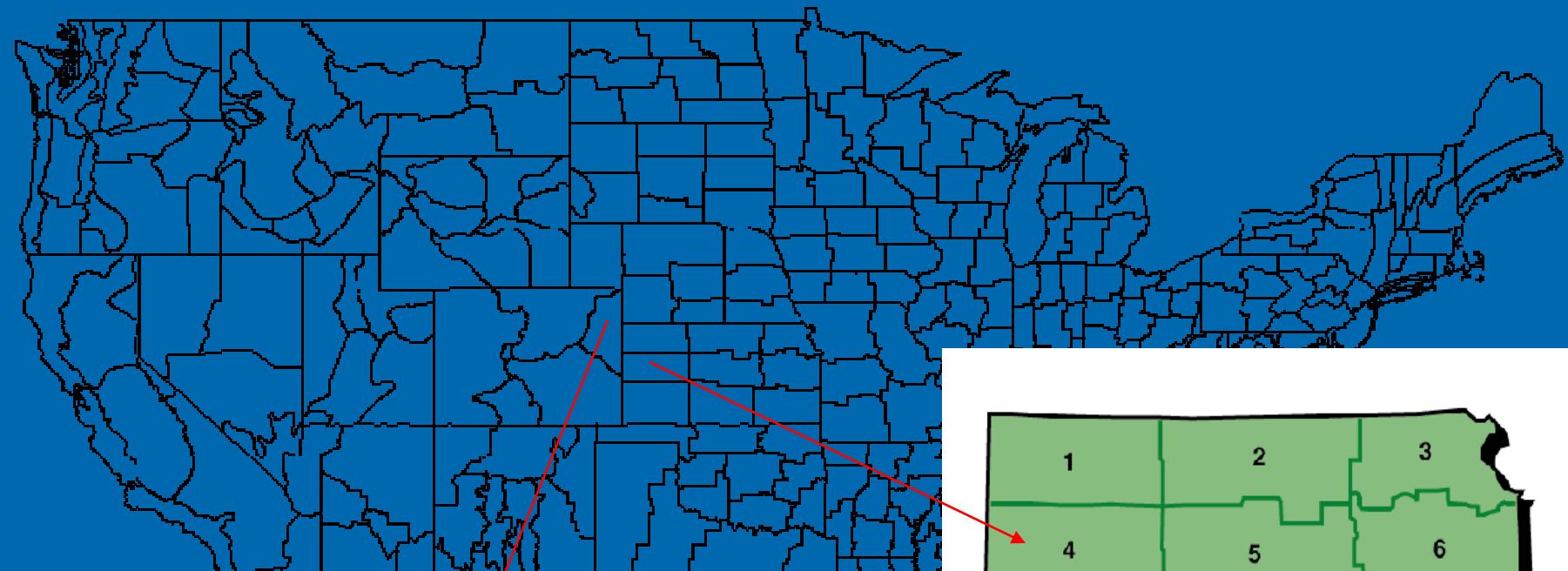


# But are we ever "Average"?

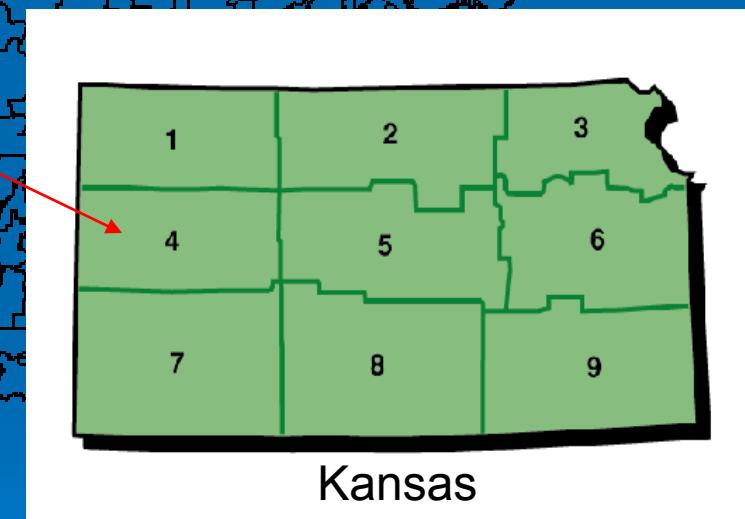
Burlington Water Year (Oct-Sep)  
Precipitation from 1892-2005



# Climate Divisions



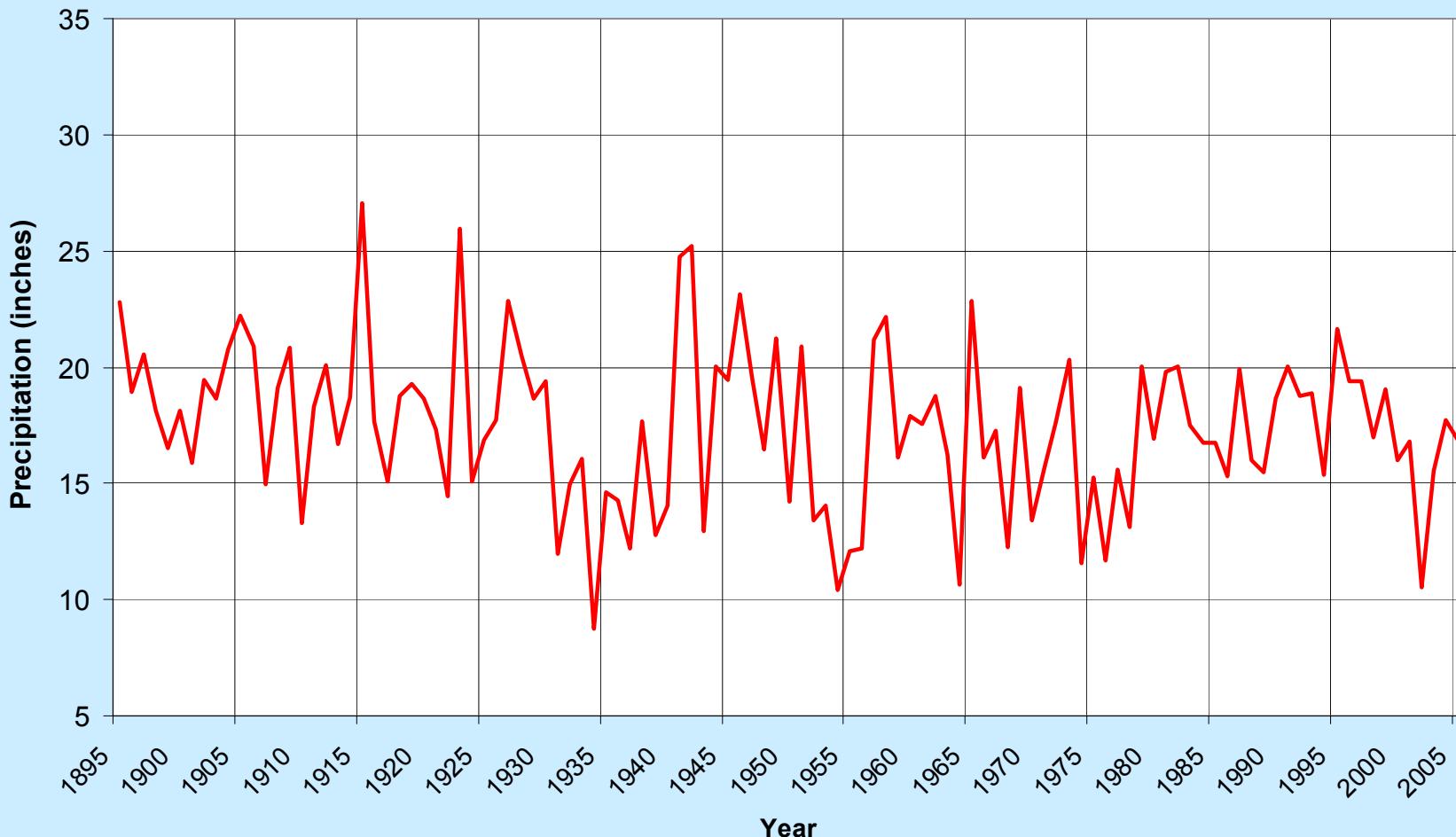
Colorado



Kansas

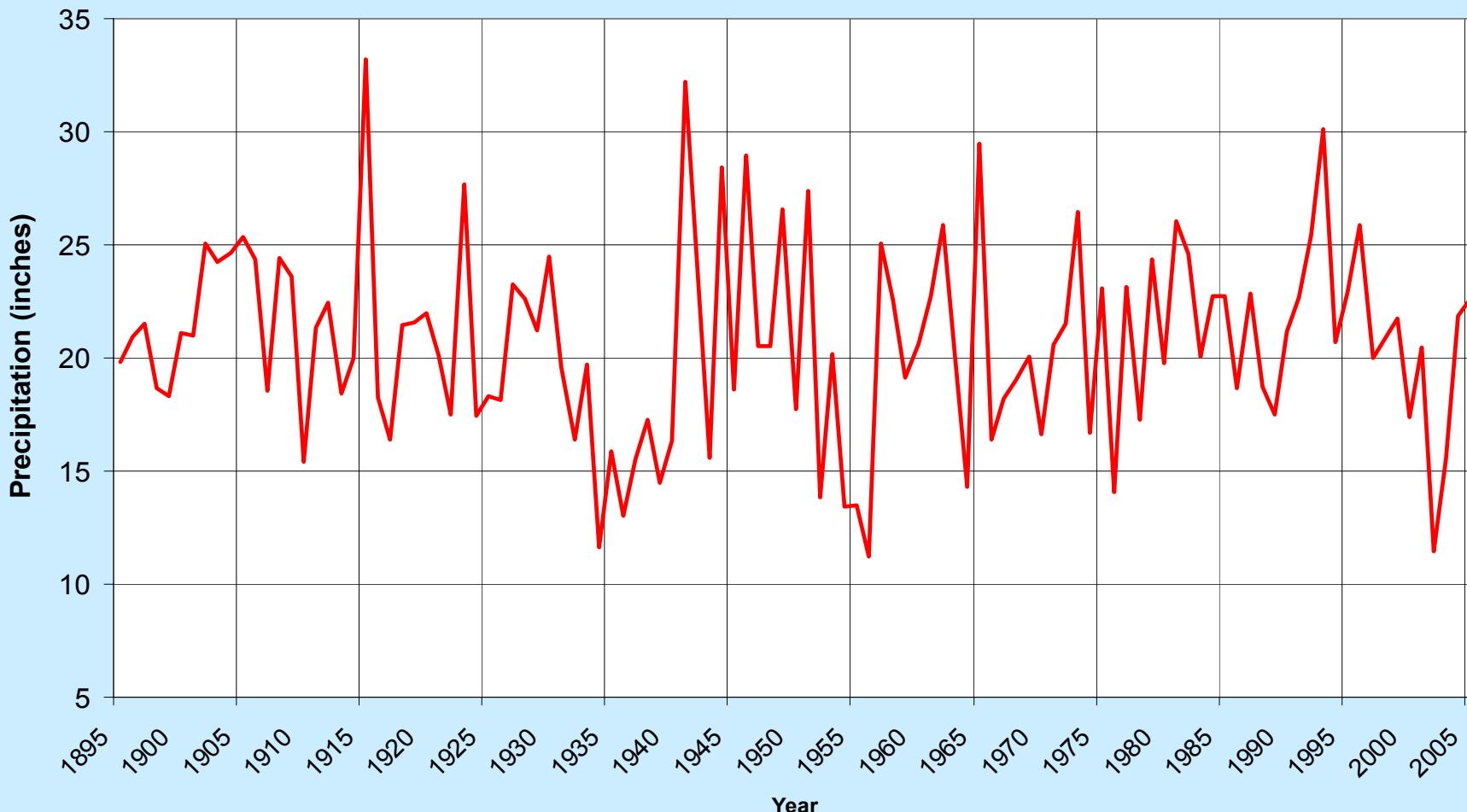
# Kansas Basin (CO-03) Annual Precipitation Totals

**Colorado (Div 3) Annual Precipitation Totals**



# Kansas Northwest Basin (KS-04) Annual Precipitation Totals

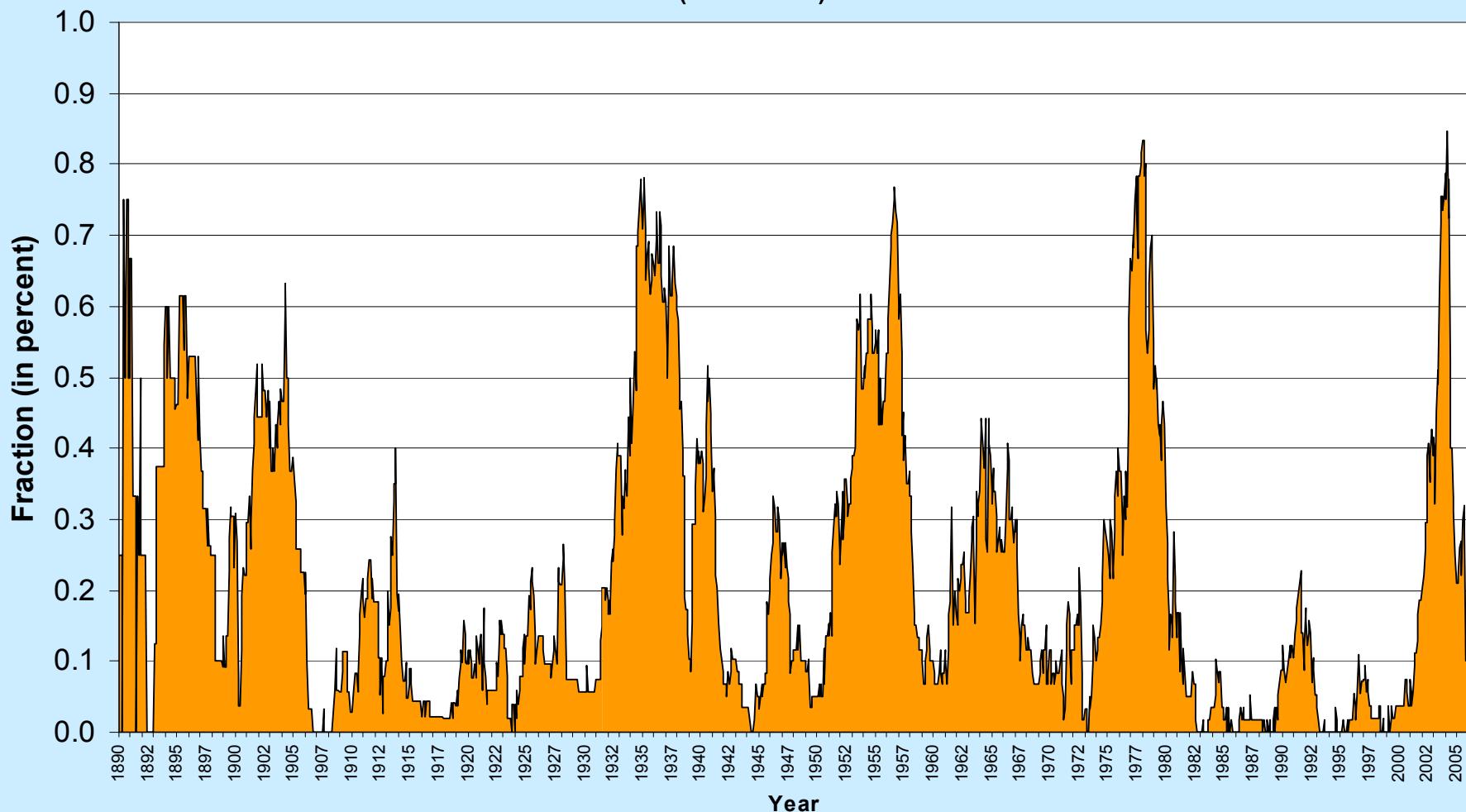
**Kansas (Div 4) Annual Precipitation Total**

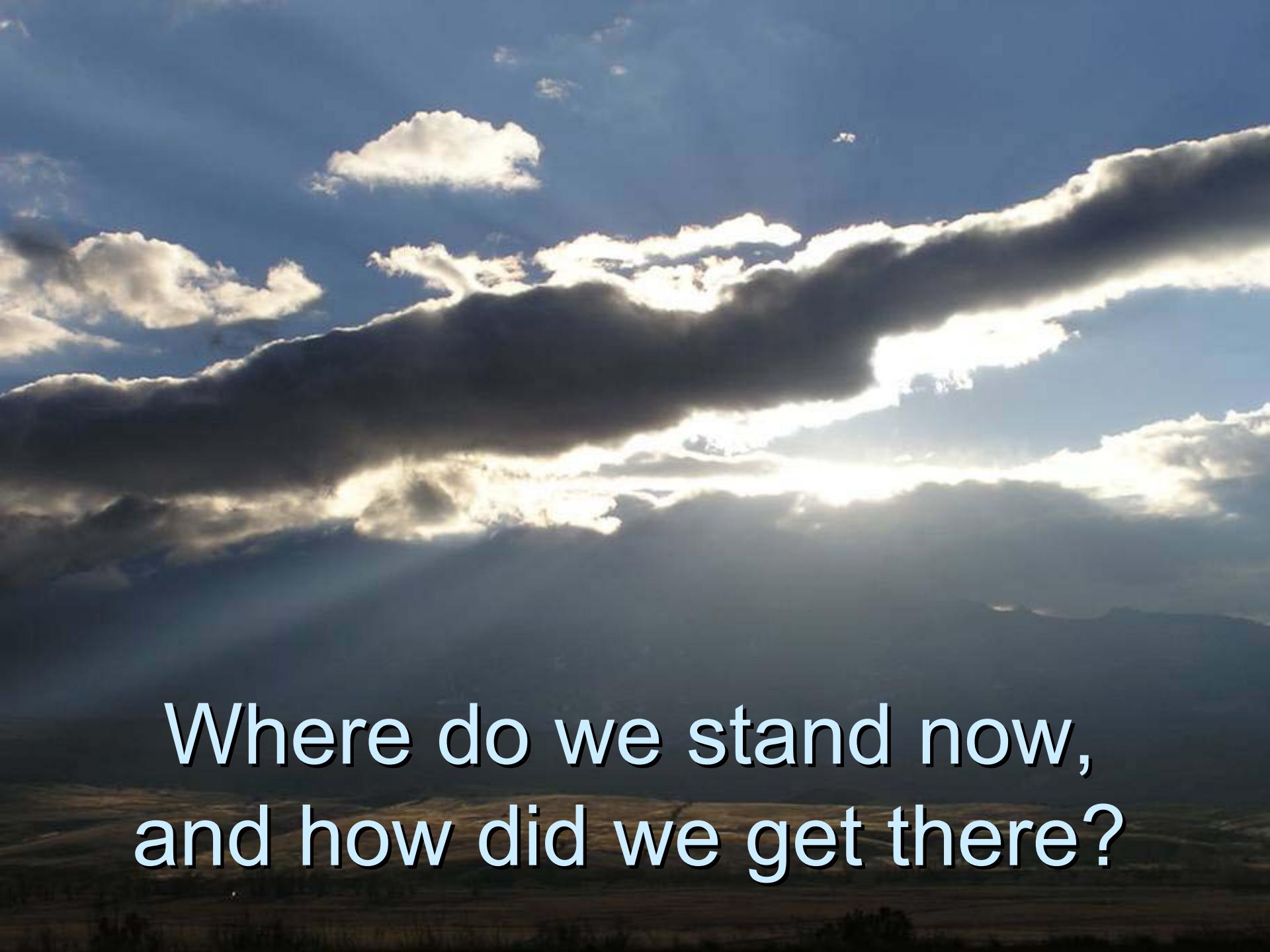


# 48-Month SPI

**Fraction of Colorado in Drought**  
**Based on 48 month SPI**

(1890 - 2005)



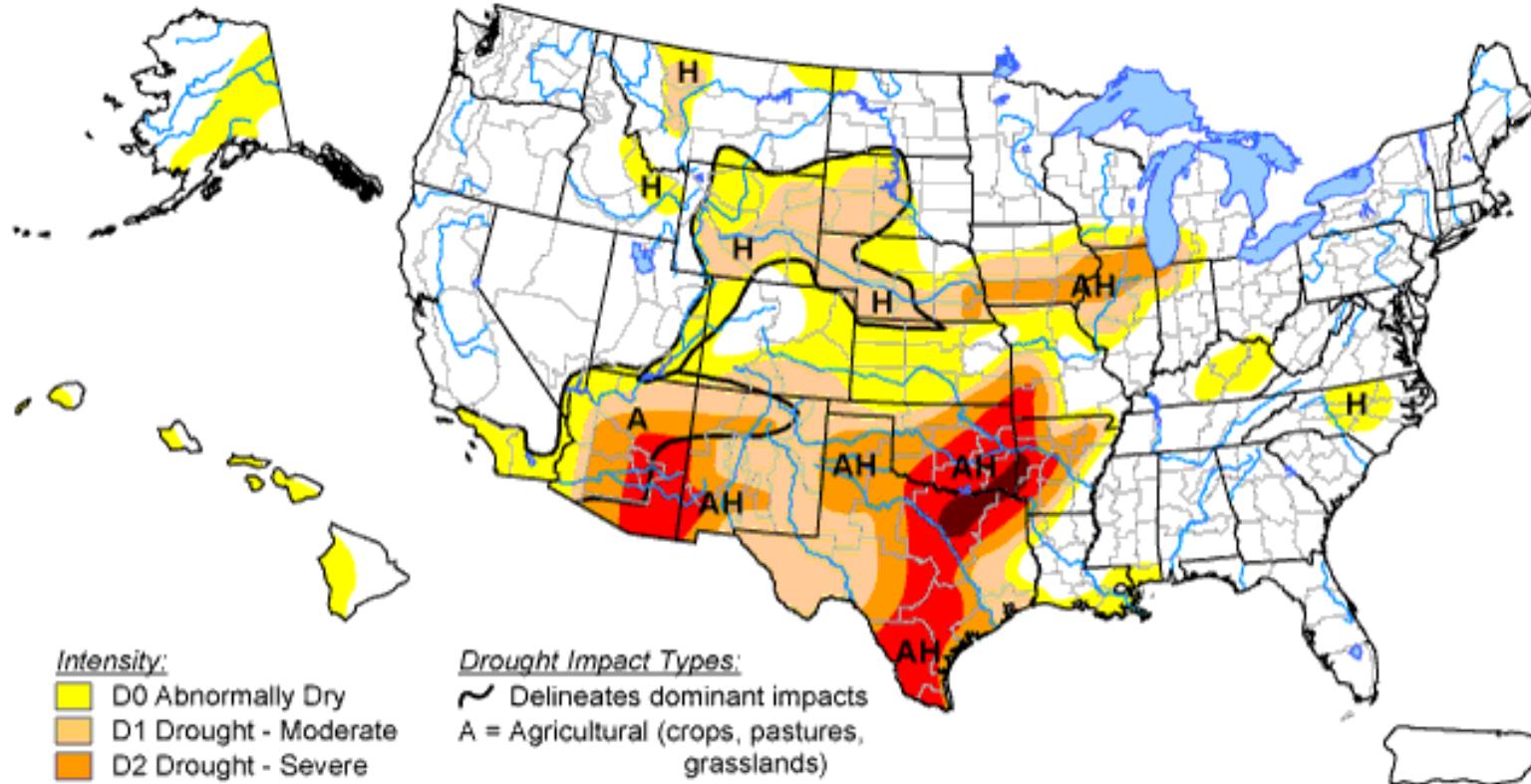


Where do we stand now,  
and how did we get there?

# Drought Monitor Map

## U.S. Drought Monitor

February 14, 2006  
Valid 7 a.m. EST



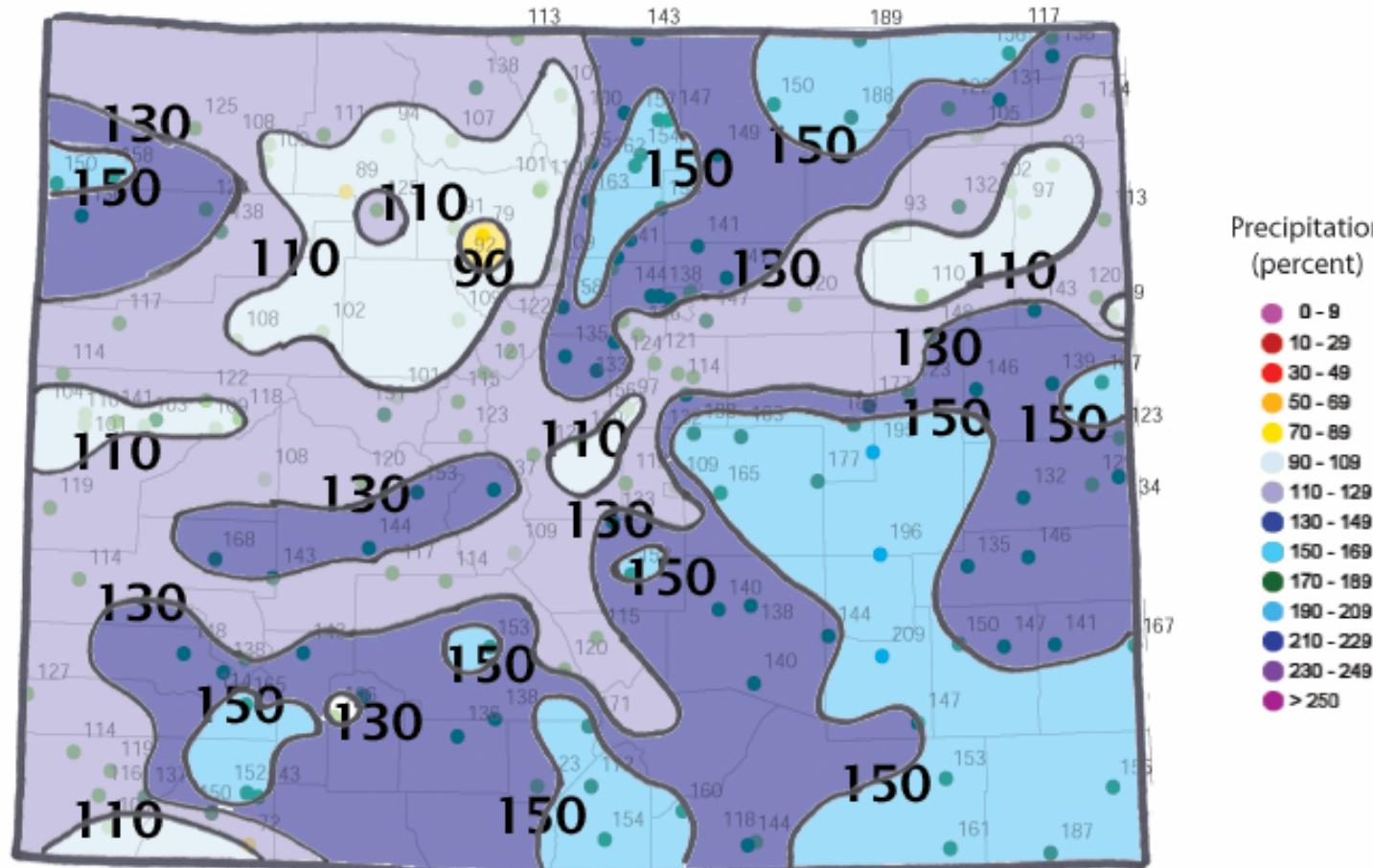
The Drought Monitor focuses on broad-scale conditions.  
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for forecast statements.



Released Thursday, February 16, 2006  
Author: David Miskus, JAWF/CPC/NOAA

# 1999 Water Year Precipitation

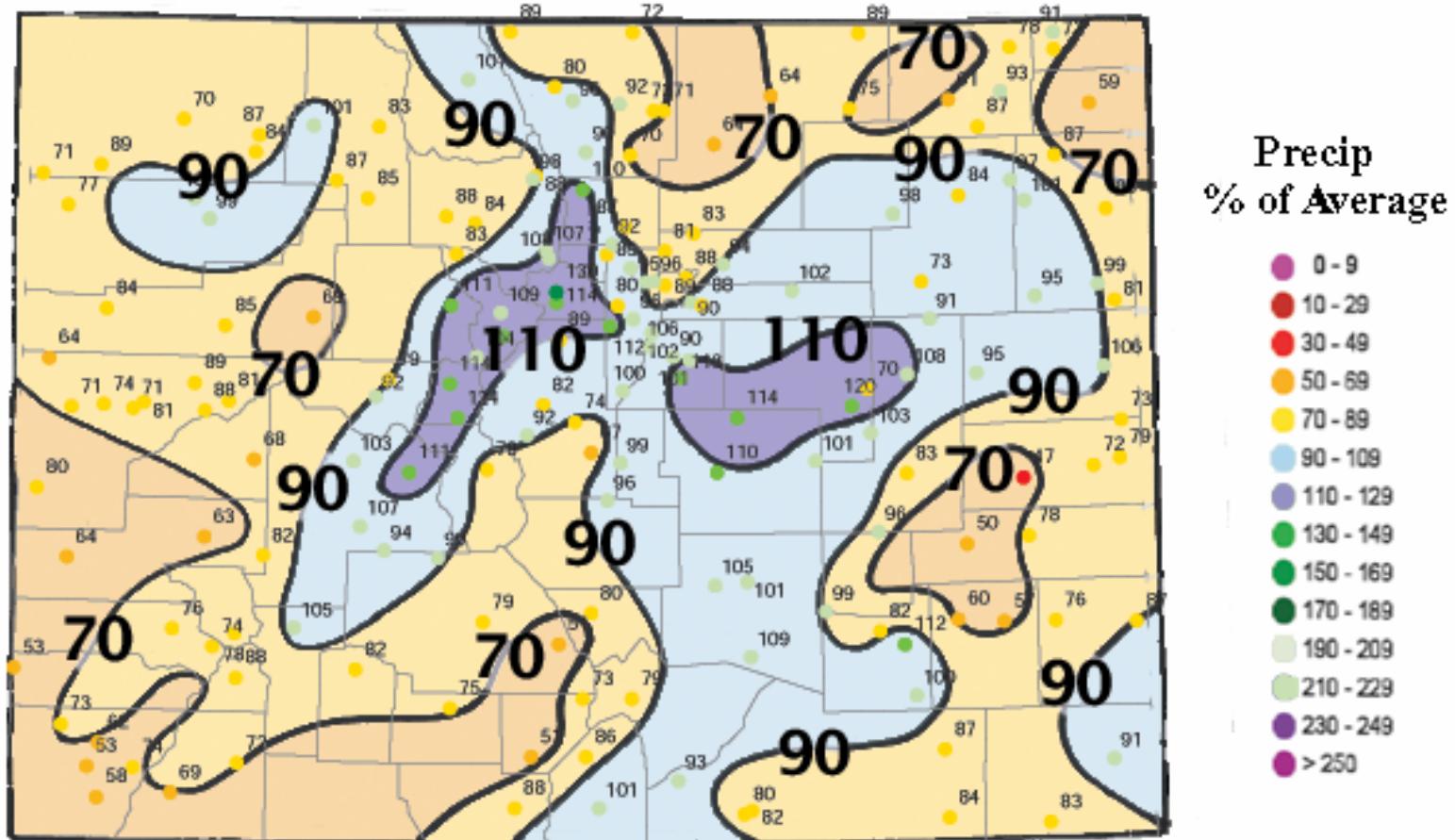
Water Year 1999  
(Oct. 1998-Sept. 1999)  
Precipitation Percent of Average for 1961-1990 Averages



# 2000 Water Year Precipitation

Water Year 2000  
(Oct. 1999 - Sept. 2000)

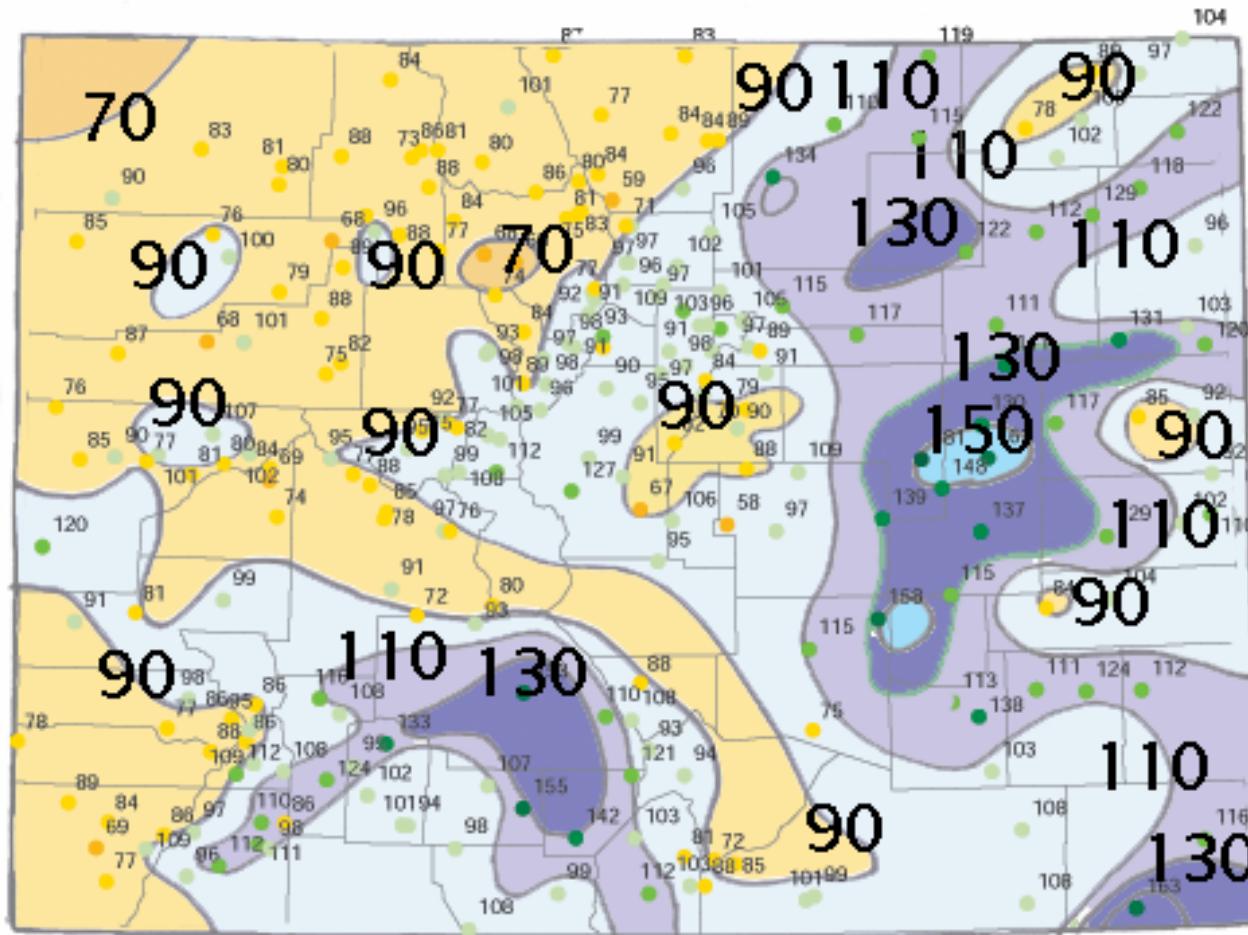
Precipitation Percent of Average for 1961-1990 Averages



# 2001 Water Year Precipitation

Water Year 2001  
(Oct. 2000 - Sept. 2001)

Precipitation Percent of Average for 1961-1990 Averages



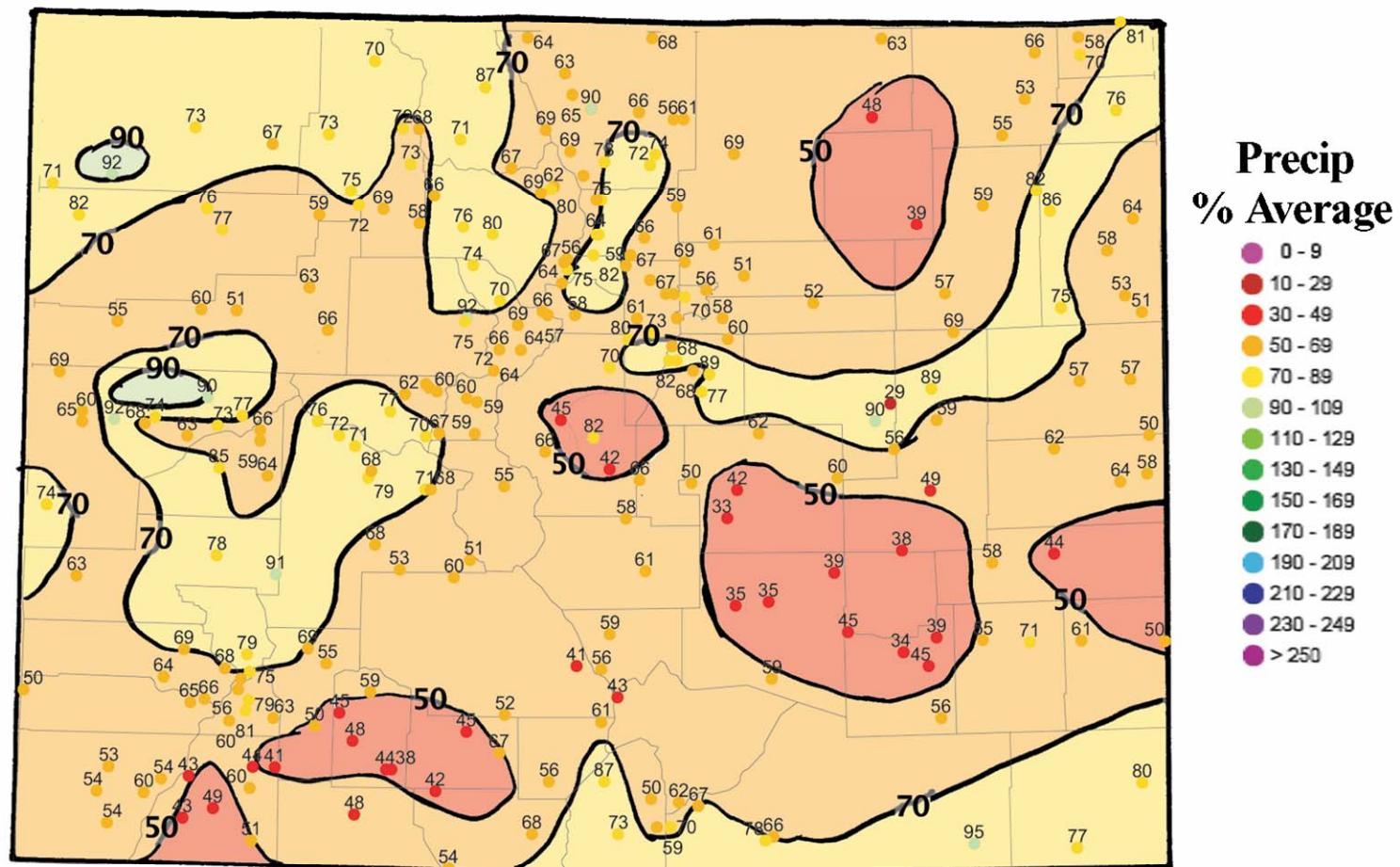
Precip  
% of Average

- 0 - 9
- 10 - 29
- 30 - 49
- 50 - 89
- 90 - 109
- 110 - 129
- 130 - 149
- 150 - 169
- 170 - 189
- 190 - 209
- 210 - 229
- 230 - 249
- > 250

# 2002 Water Year Precipitation

Water Year 2002  
(Oct. 2001 - Sept. 2002)

Precipitation Percent of Average for 1961-1990 Averages

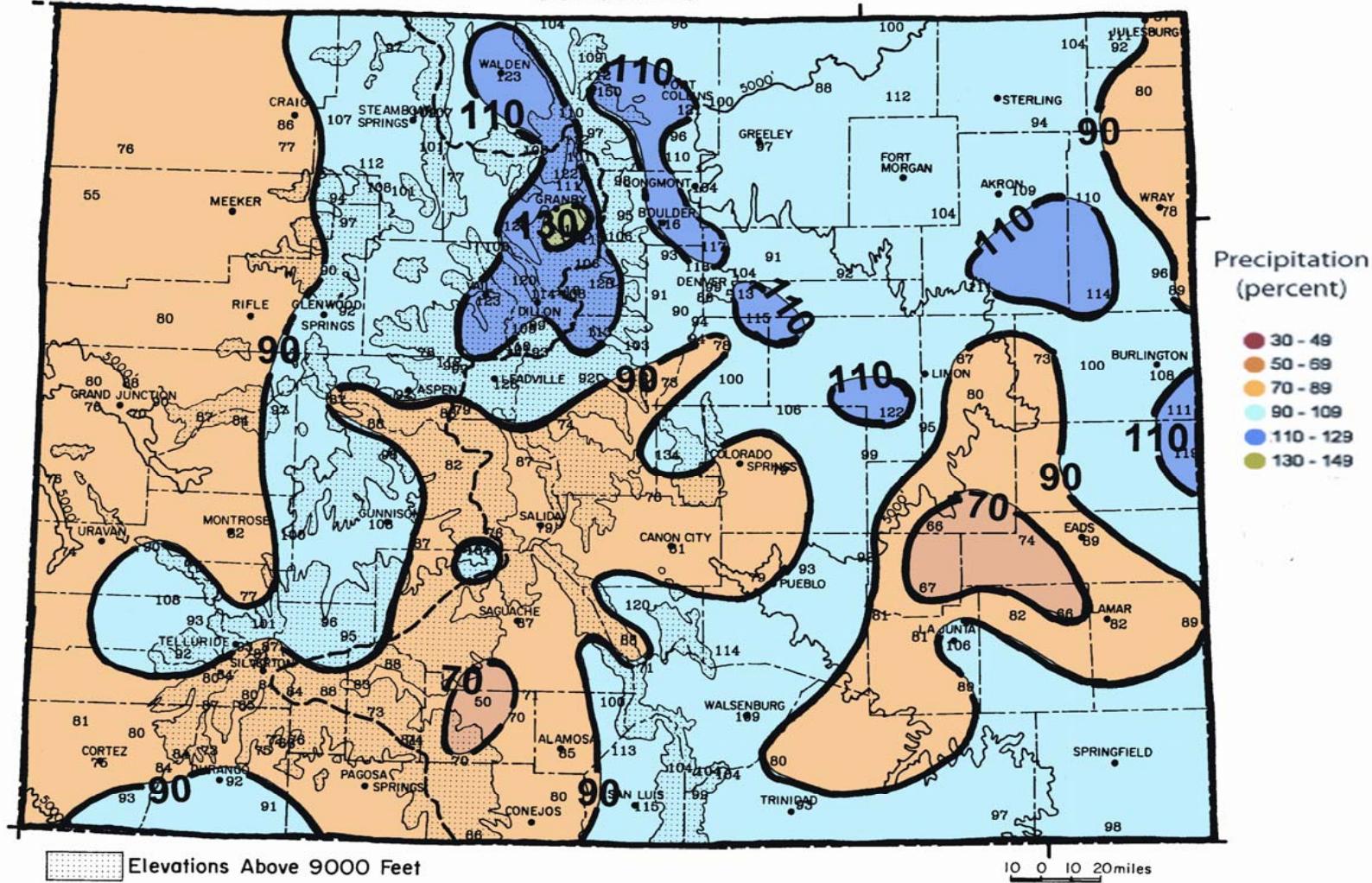


# 2003 Water Year Precipitation

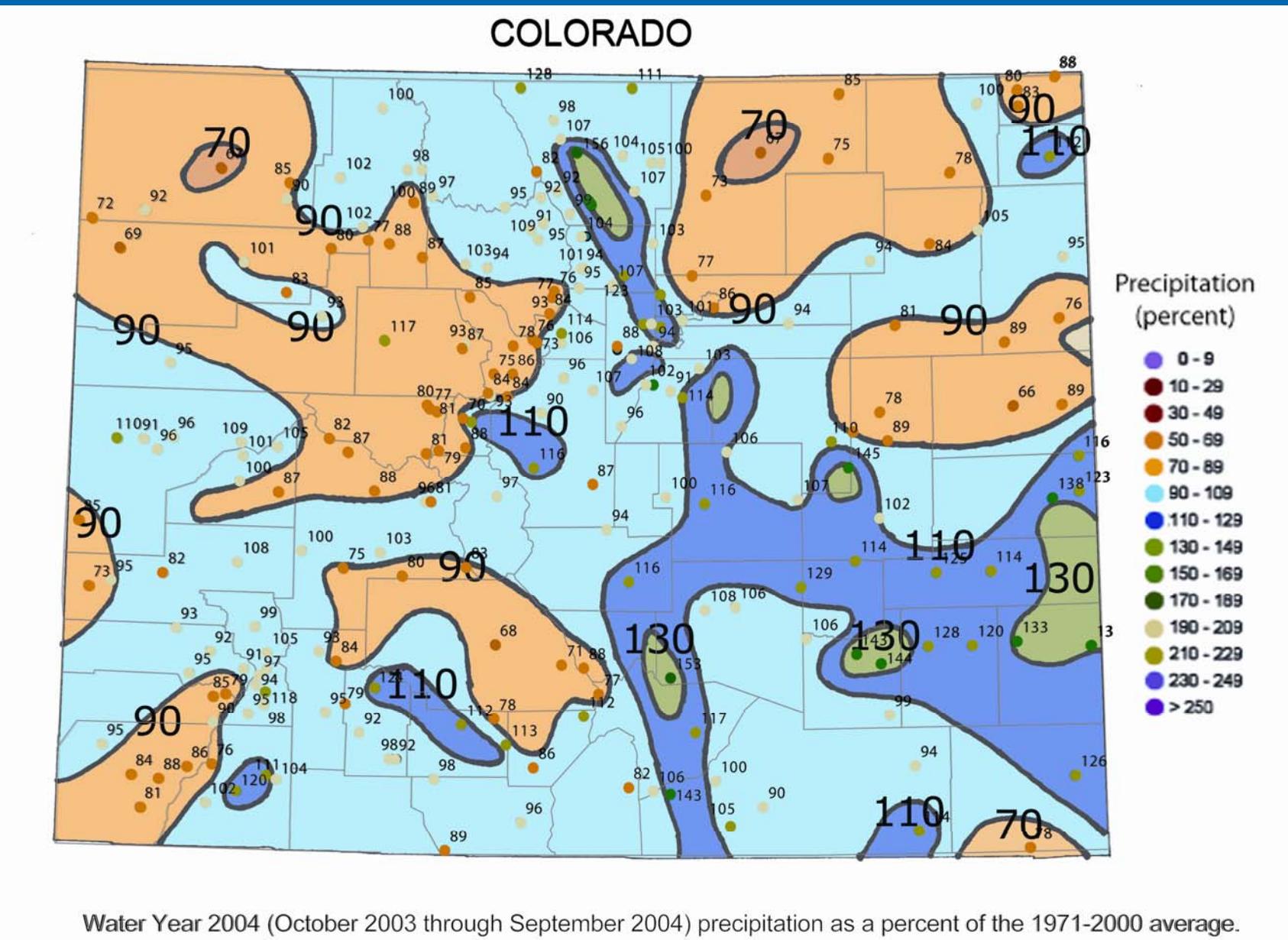
## Water Year 2003

October 2002 - September 2003 precipitation  
as a percent of the 1971-2000 average.

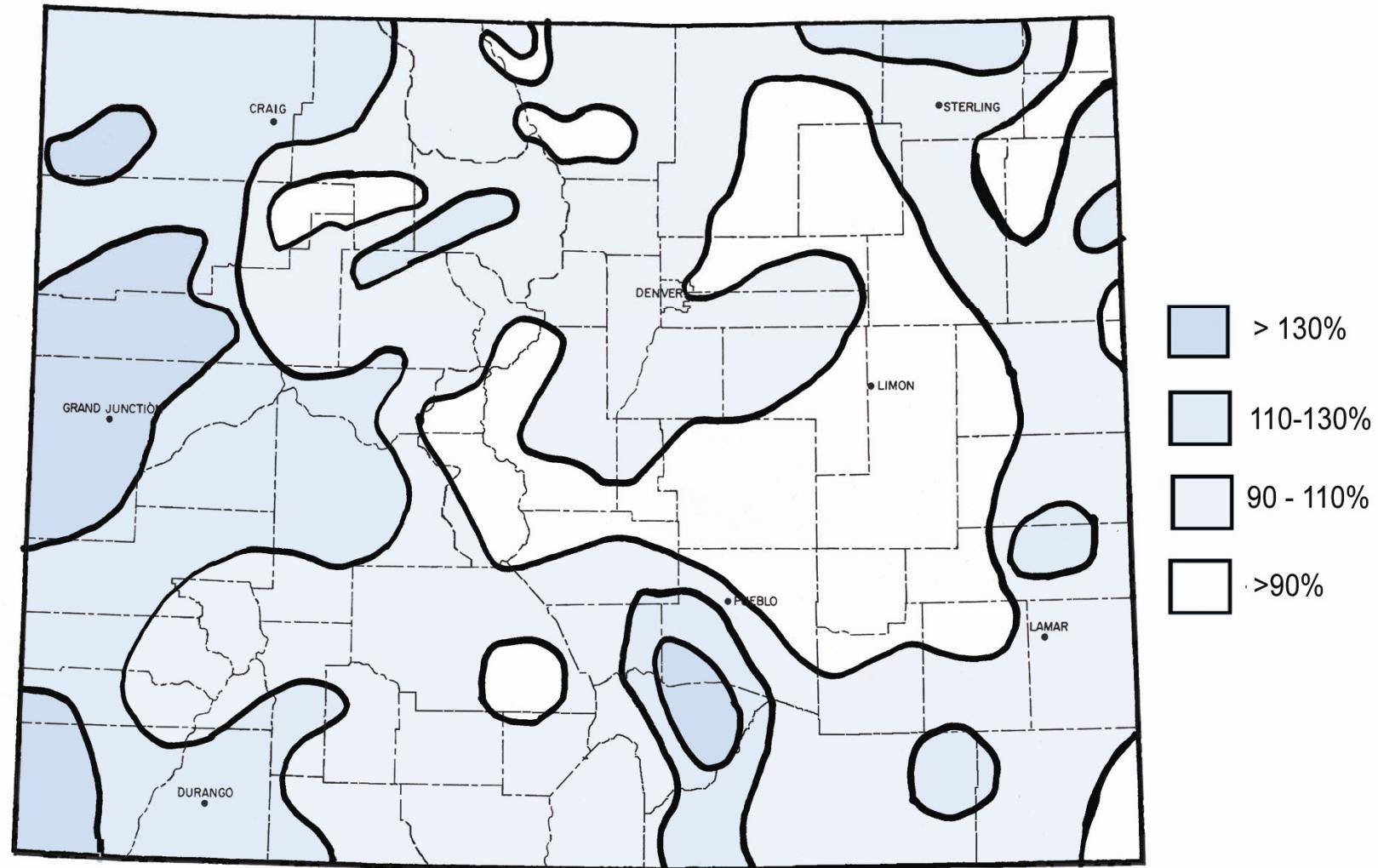
### COLORADO



# 2004 Water Year Precipitation



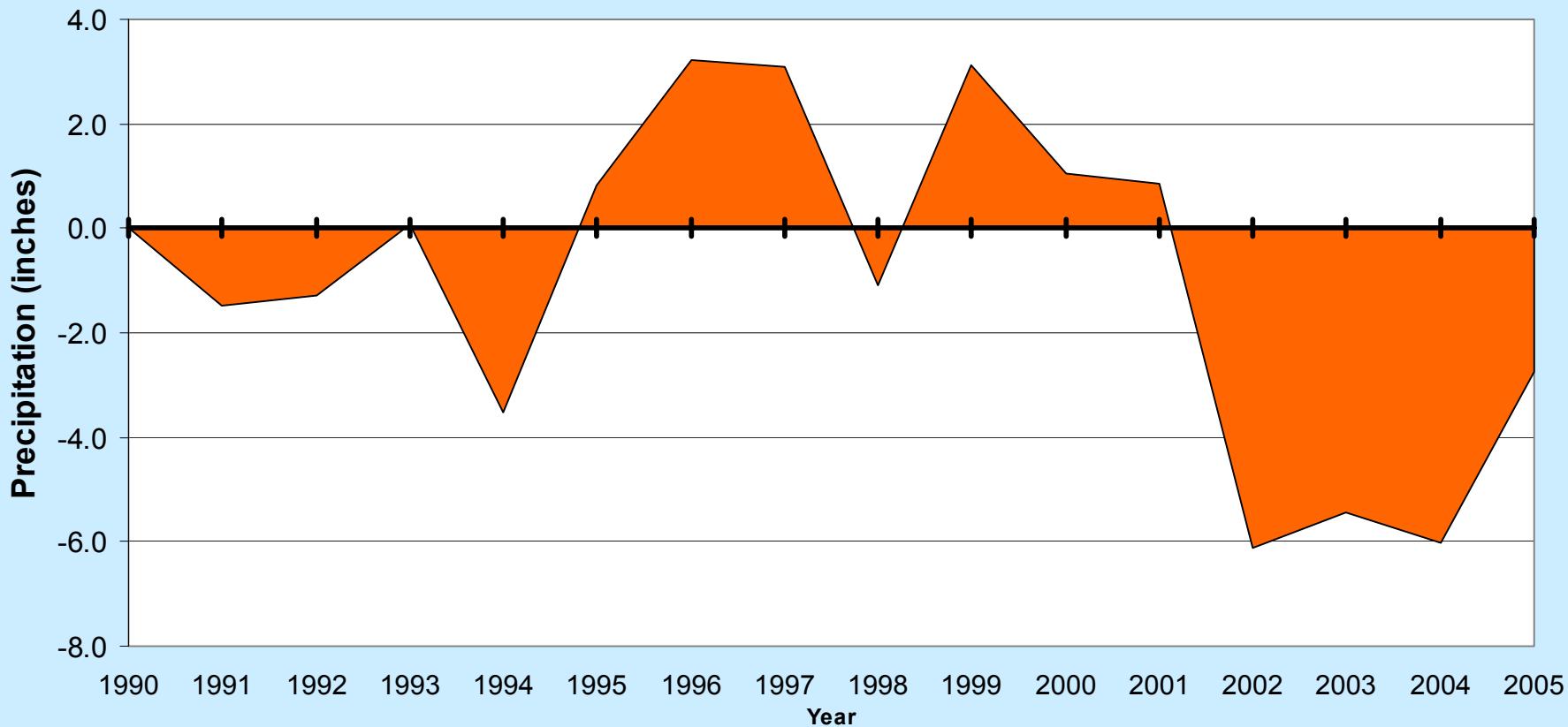
# 2005 Water Year Precipitation as Percent of Average



Water Year 2005 (Oct 04 - Sept. 05) precipitation as a percent of the 1971-2000 average.

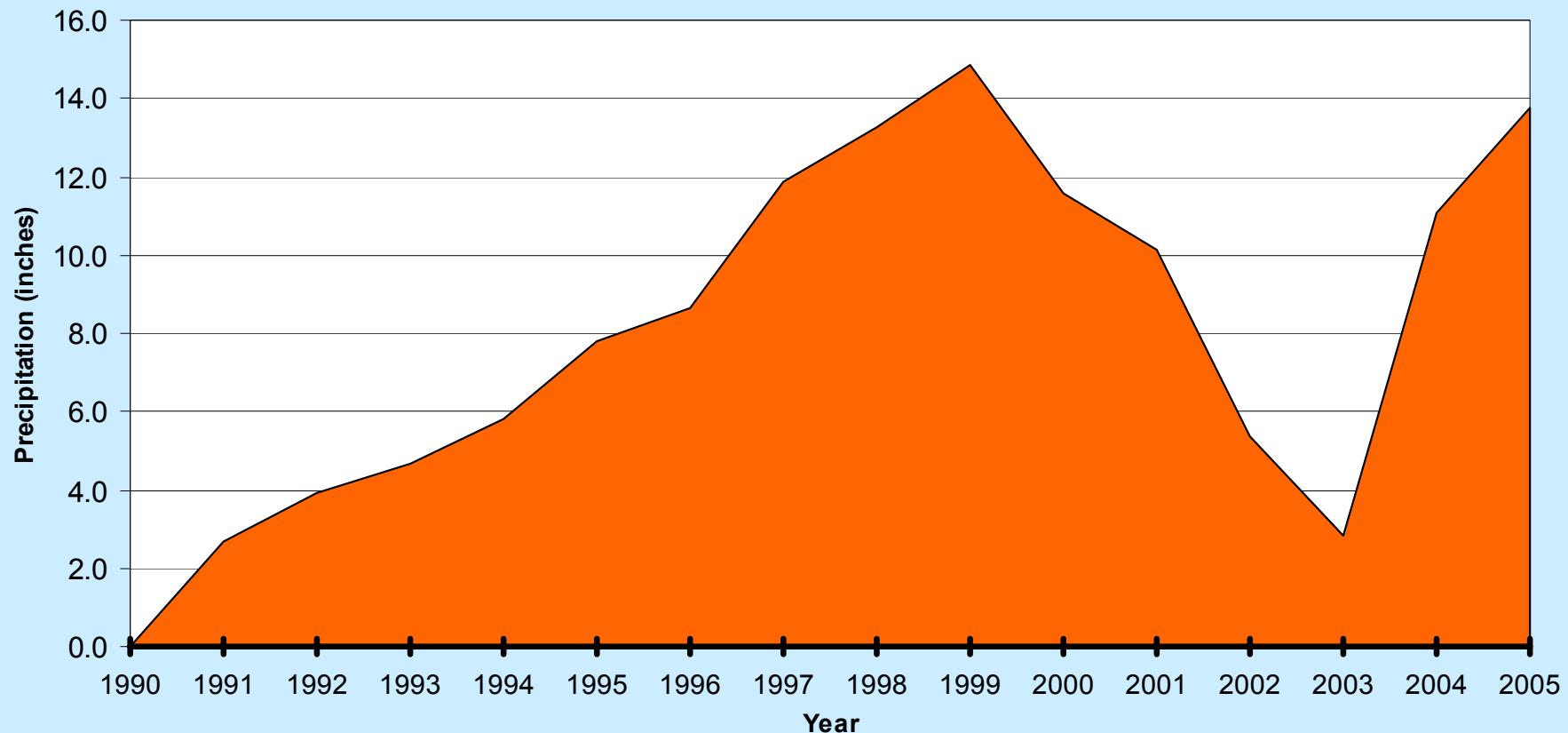
# Akron Accumulated Precipitation Deficit

**Akron 4E**  
**Accumulated Precipitation Deficit**  
since 1990 compared to 1971-2000 average



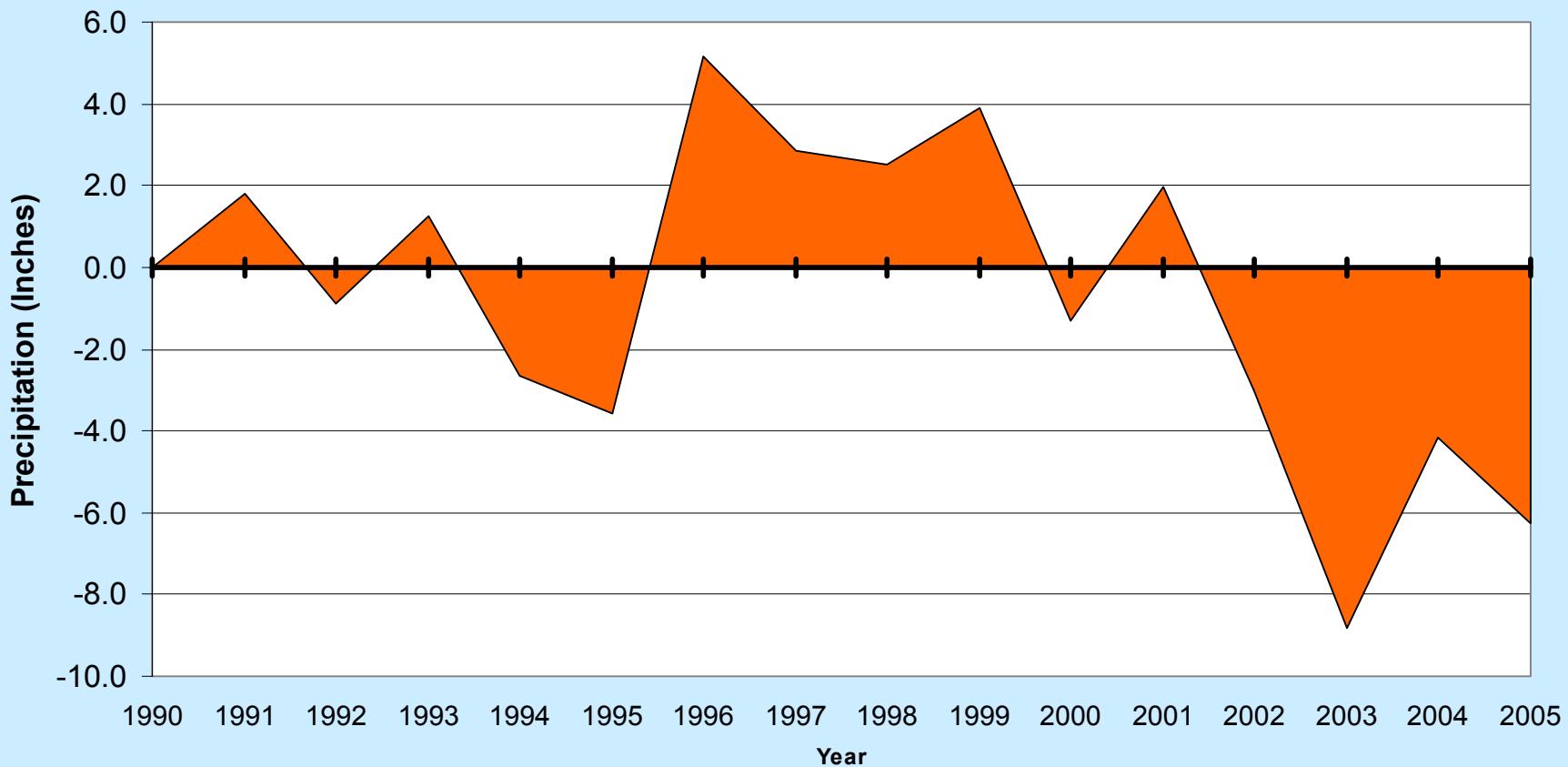
# Cheyenne Wells Accumulated Precipitation

Cheyenne Wells  
Accumulated Precipitation Deficit  
since 1990 compared to 1971-2000 average



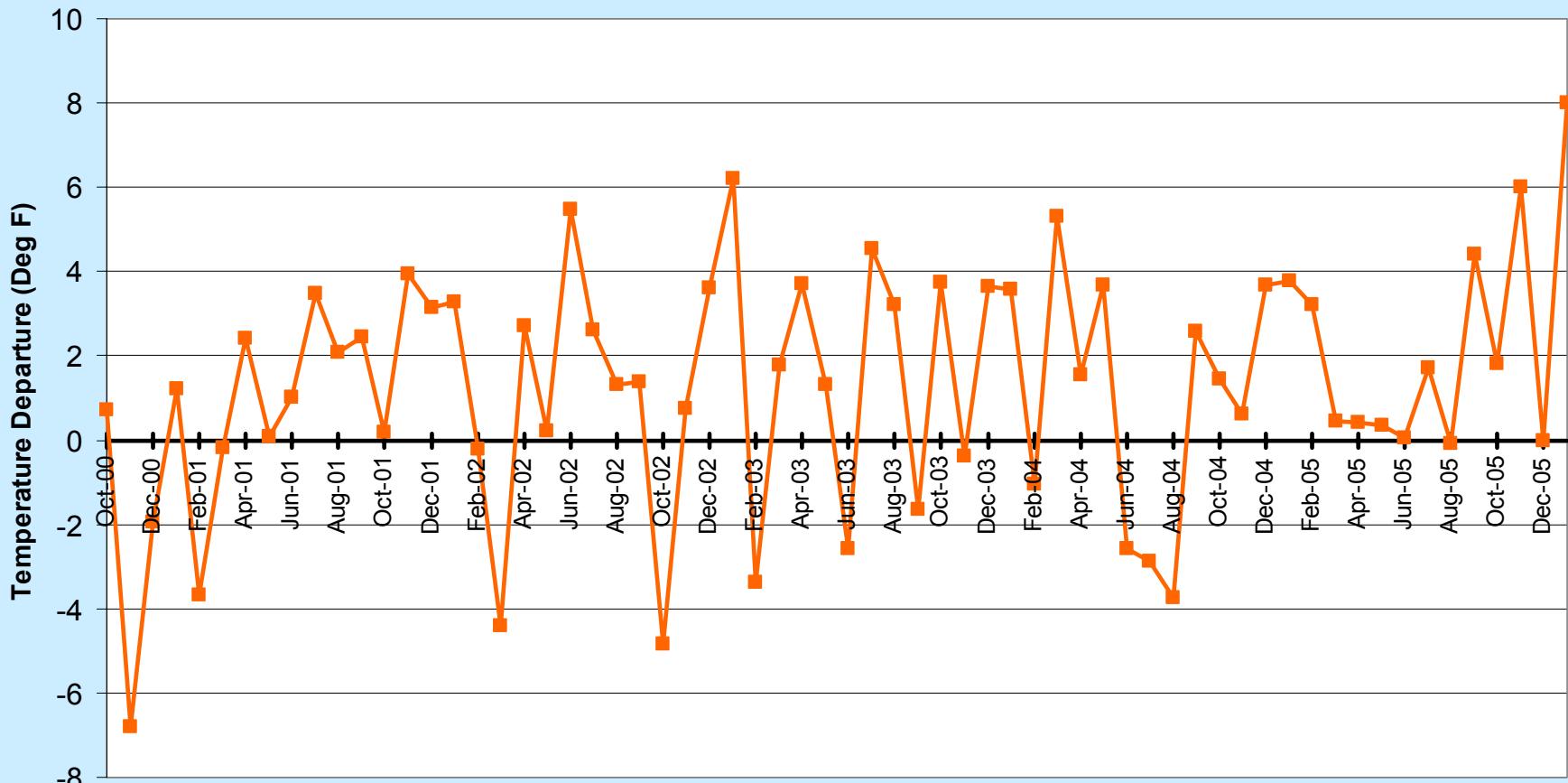
# Holyoke Accumulated Precipitation

Holyoke, Colorado  
Accumulated Precipitation Deficit  
since 1990 compared to 1971-2005 average



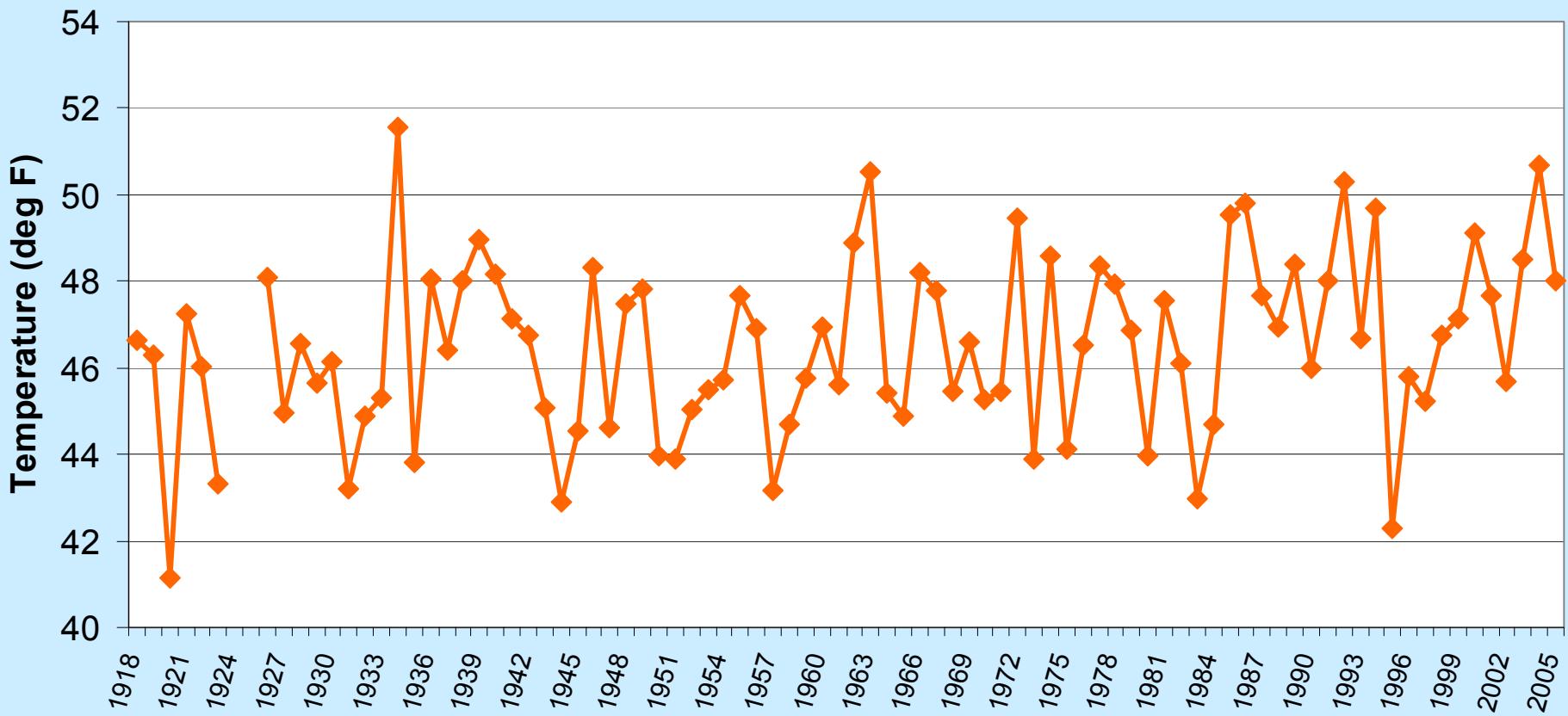
# Eastern Plains Temperature Departures from Average

Eastern Plains Departure from Average (deg F)  
from October 2000 to January 2006



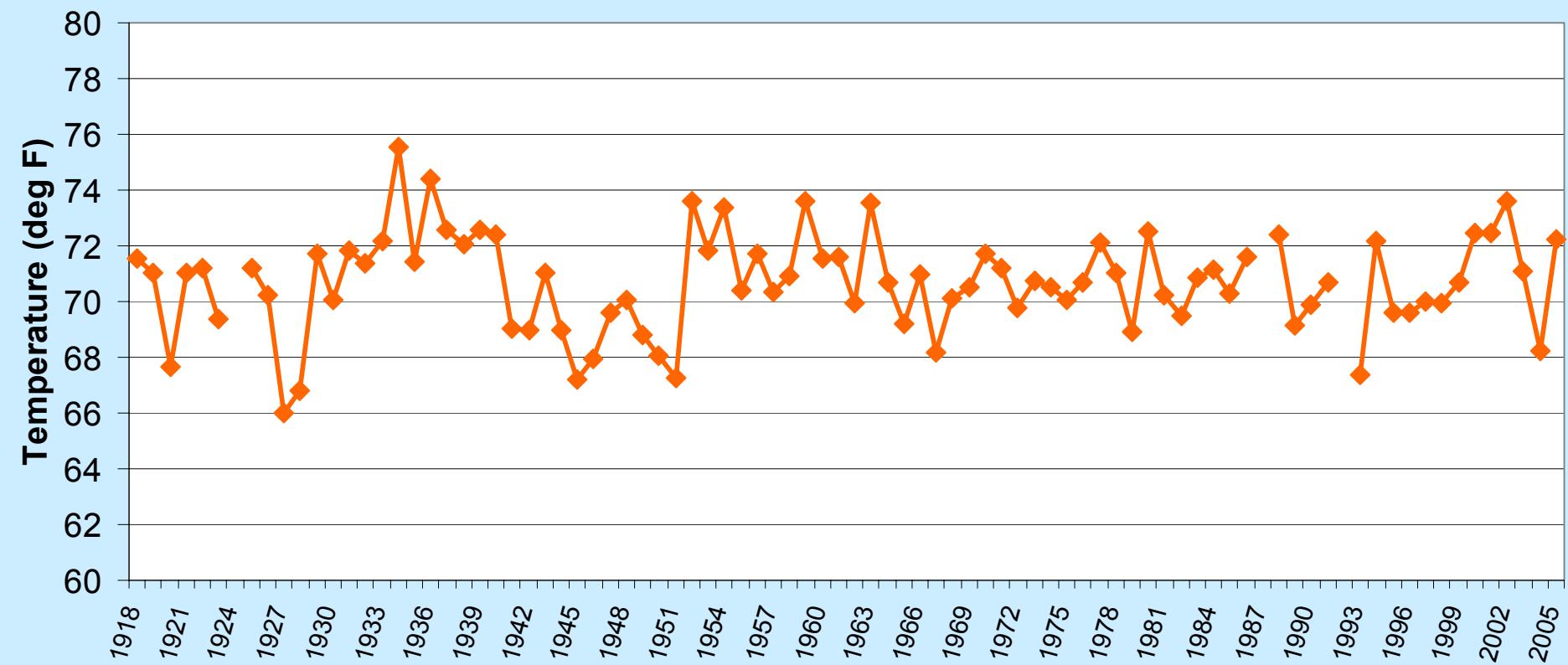
# Akron Spring Temperatures

Akron Average Temperatures  
Spring (Mar-May)



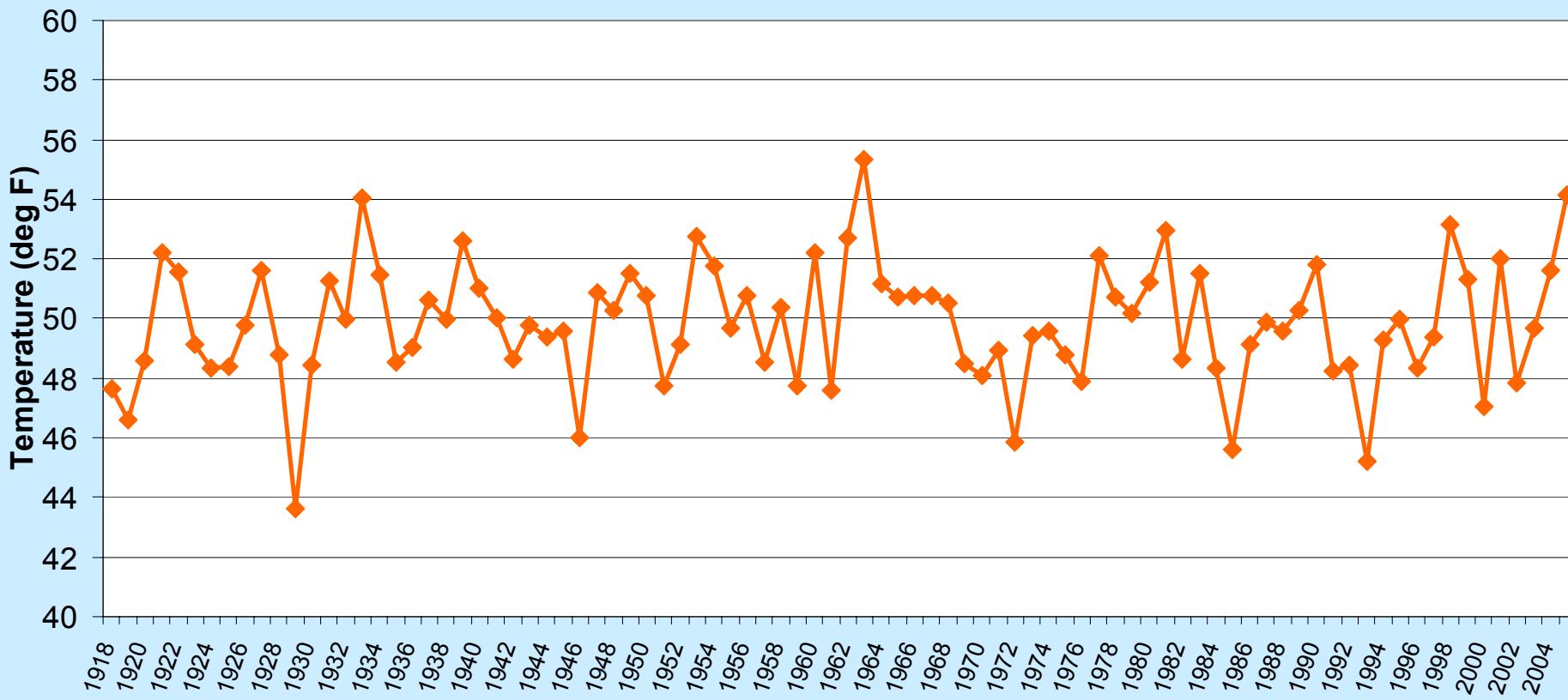
# Akron Summer Temperatures

Akron Average Temperatures  
Summer (Jun-Aug)



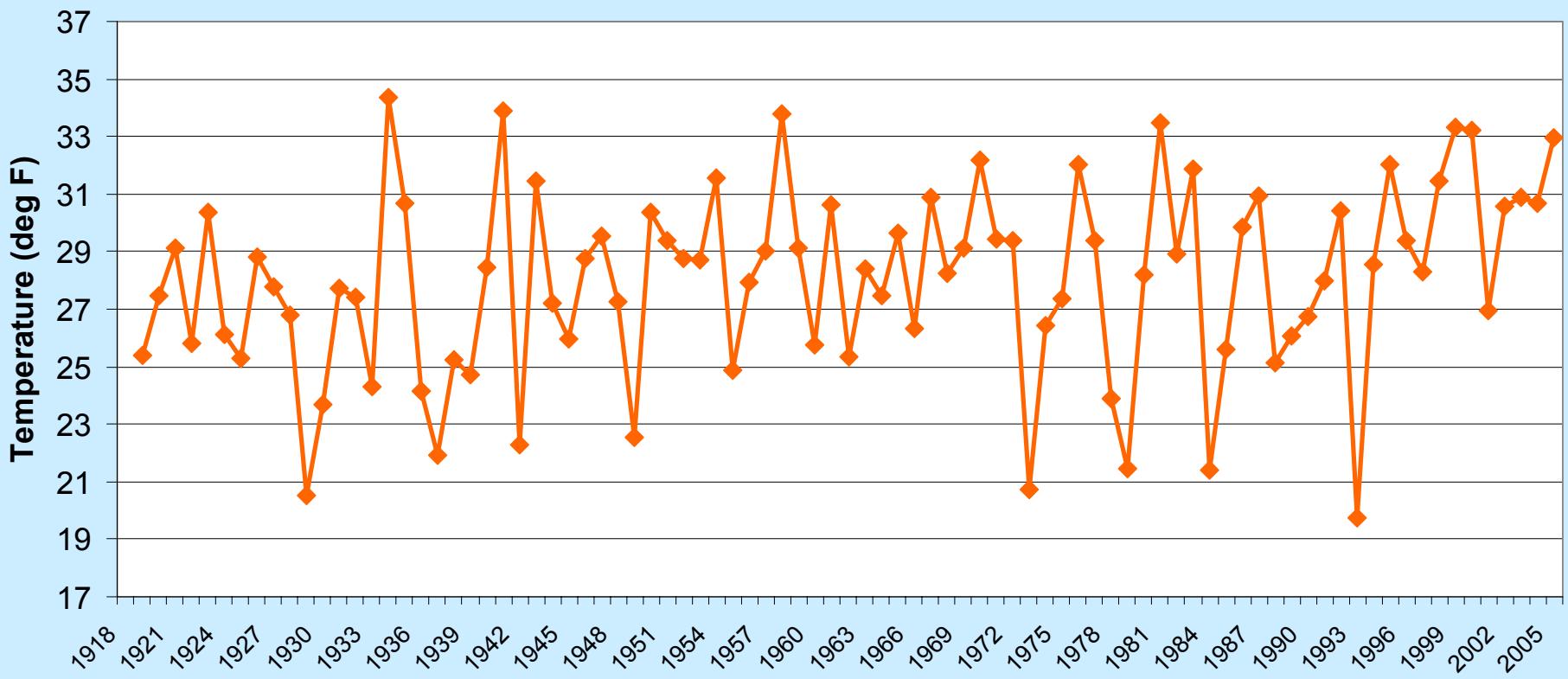
# Akron Fall Temperatures

Akron Average Temperatures  
Fall (Sep-Nov)

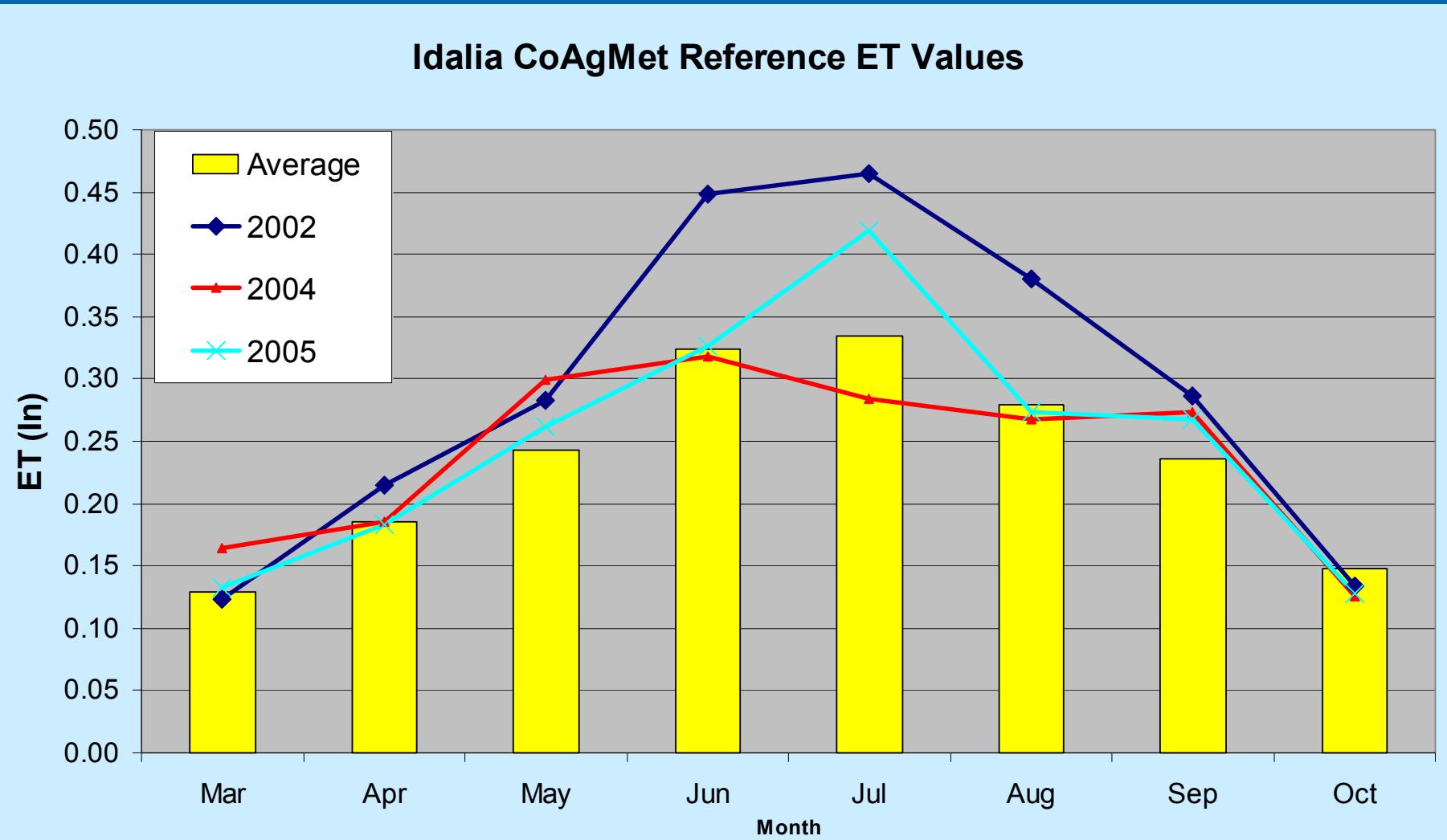


# Akron Winter Temperatures

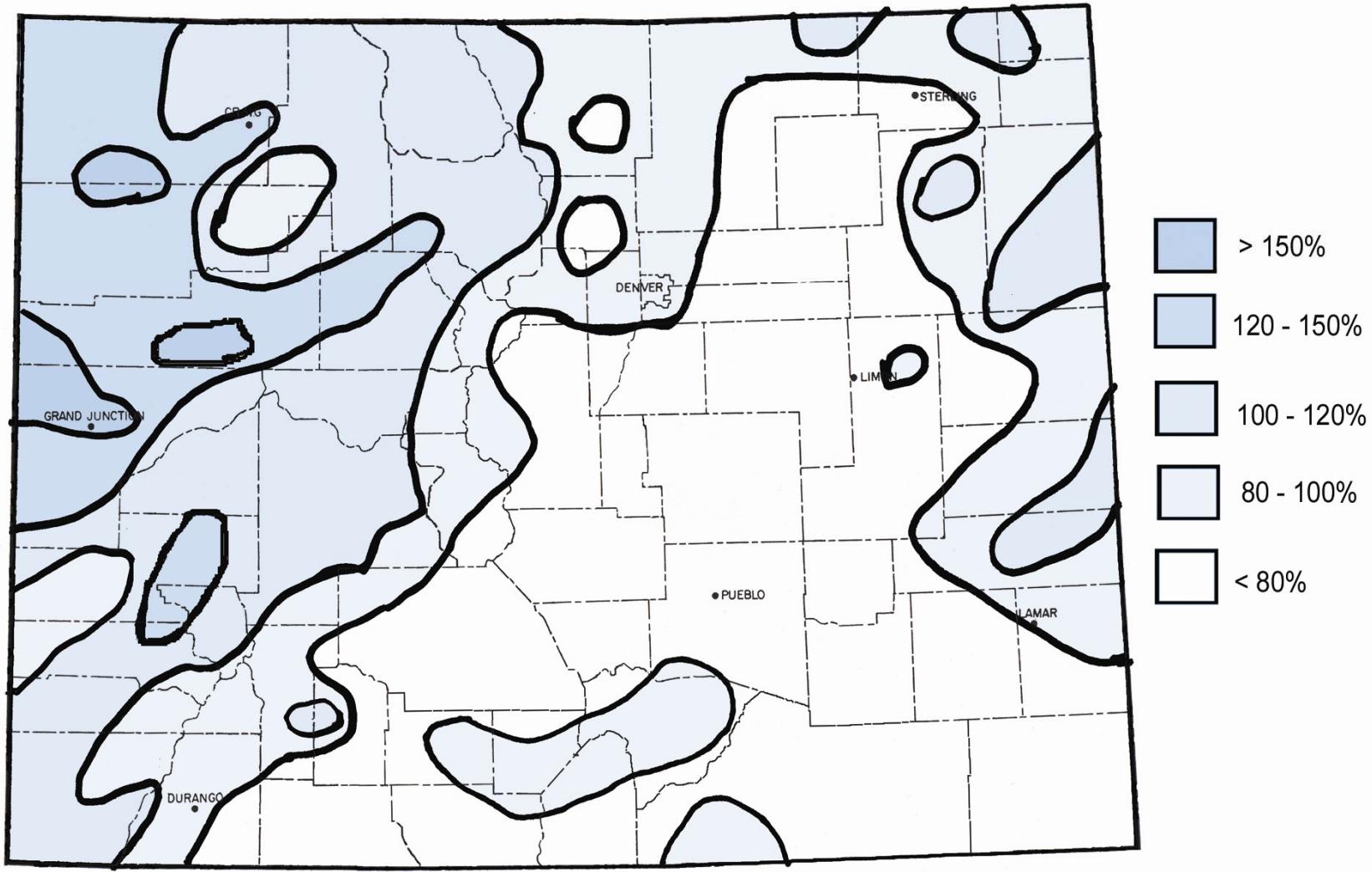
**Akron Average Temperatures  
Winter (Dec-Feb)**



# Idalia CoAgMet Reference ET

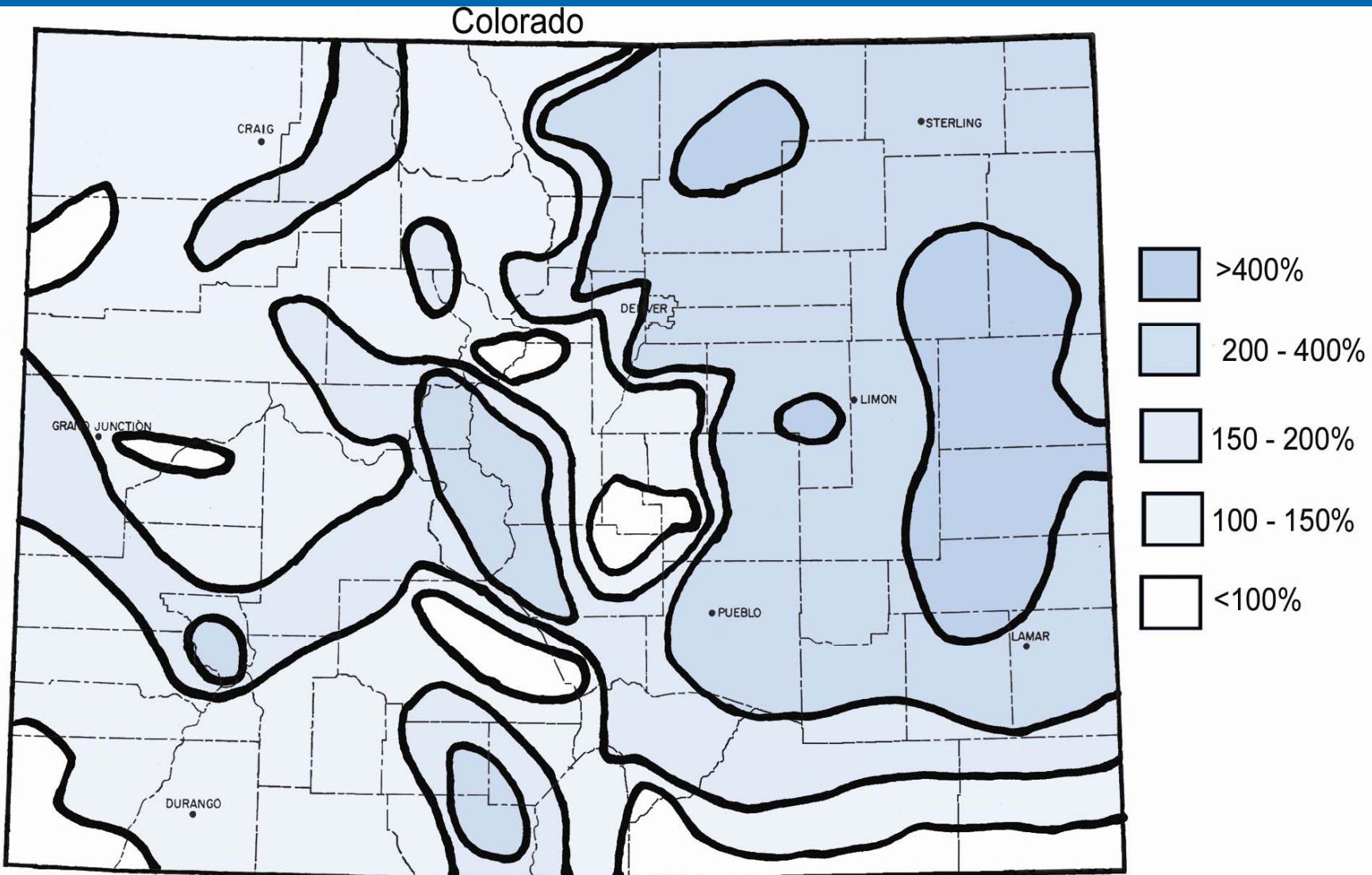


# Summer (May – Sep) 2005 precipitation as percent of average



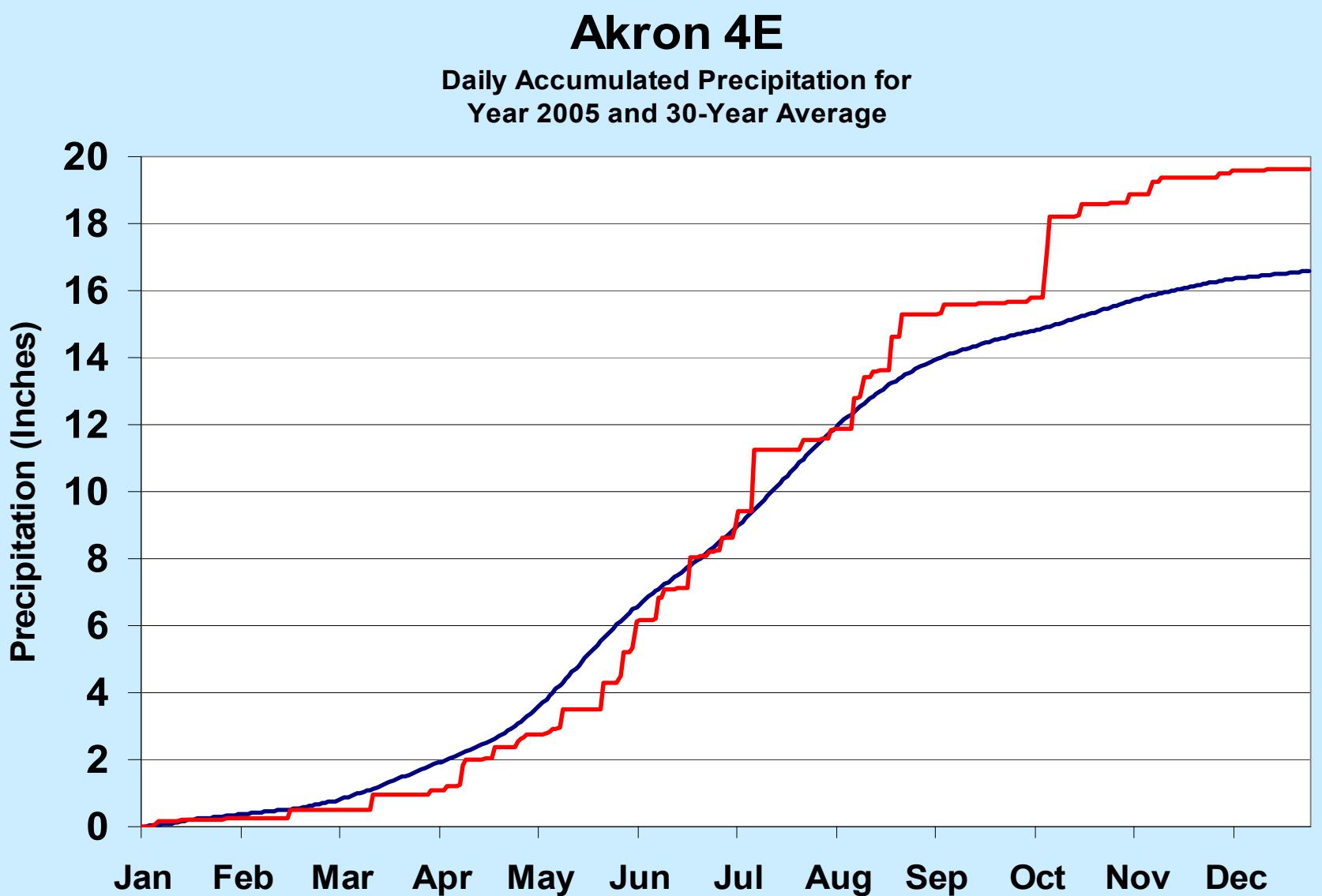
Summer (May - September) 2005 precipitation as a percent of the 1971-2000 average.

# October 2005 Precipitation as Percent of Average

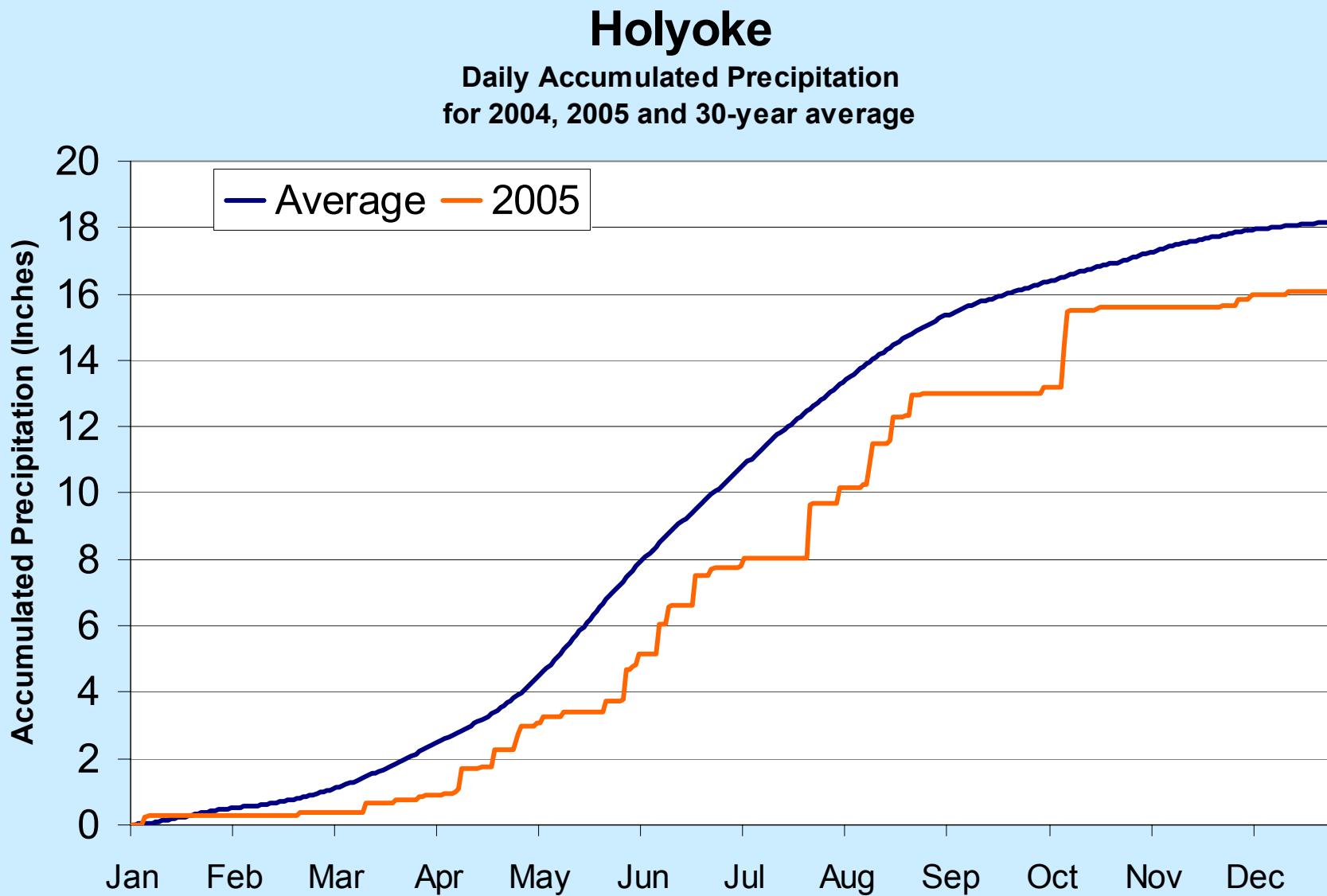


October 2005 precipitation as a percent of the 1971 - 2000 average.

# Akron 2005 daily precipitation compared to daily average

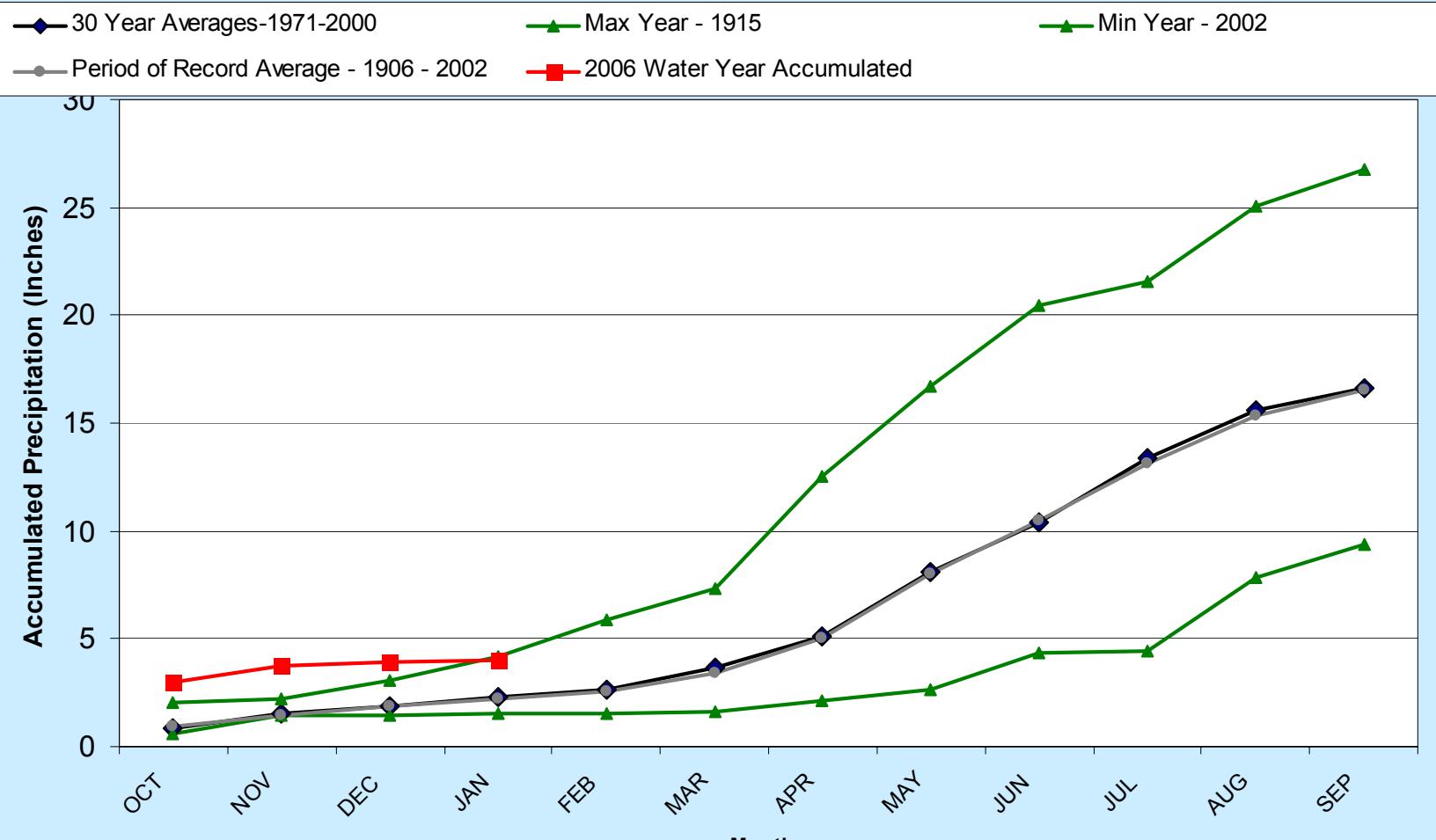


# Holyoke, 2004 & 2005 daily accumulated precipitation compared to daily average



# Akron 4E 2006 Water Year

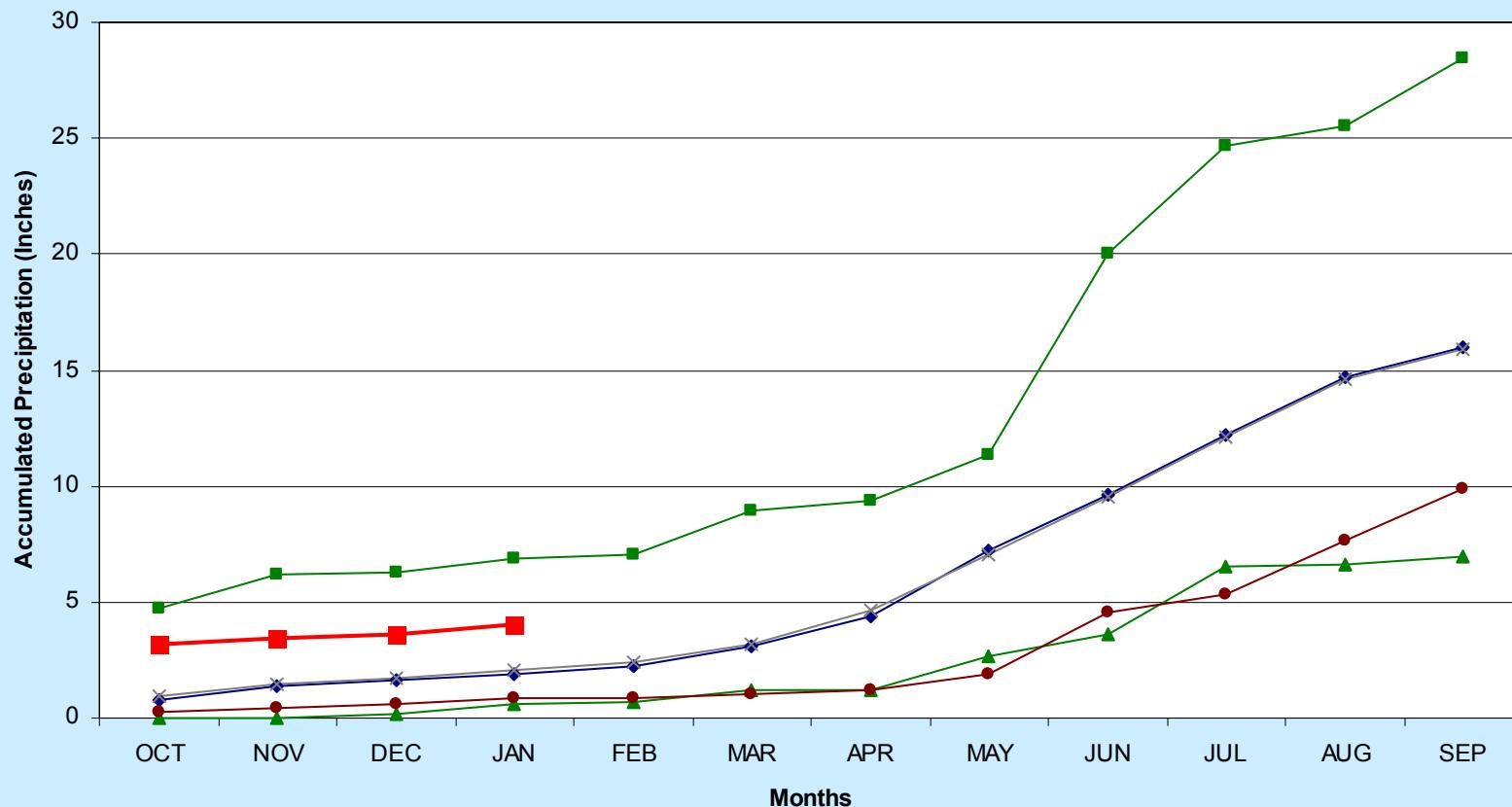
## Akron 4E 2006 Water Year



# Cheyenne Wells 2006 Water Year

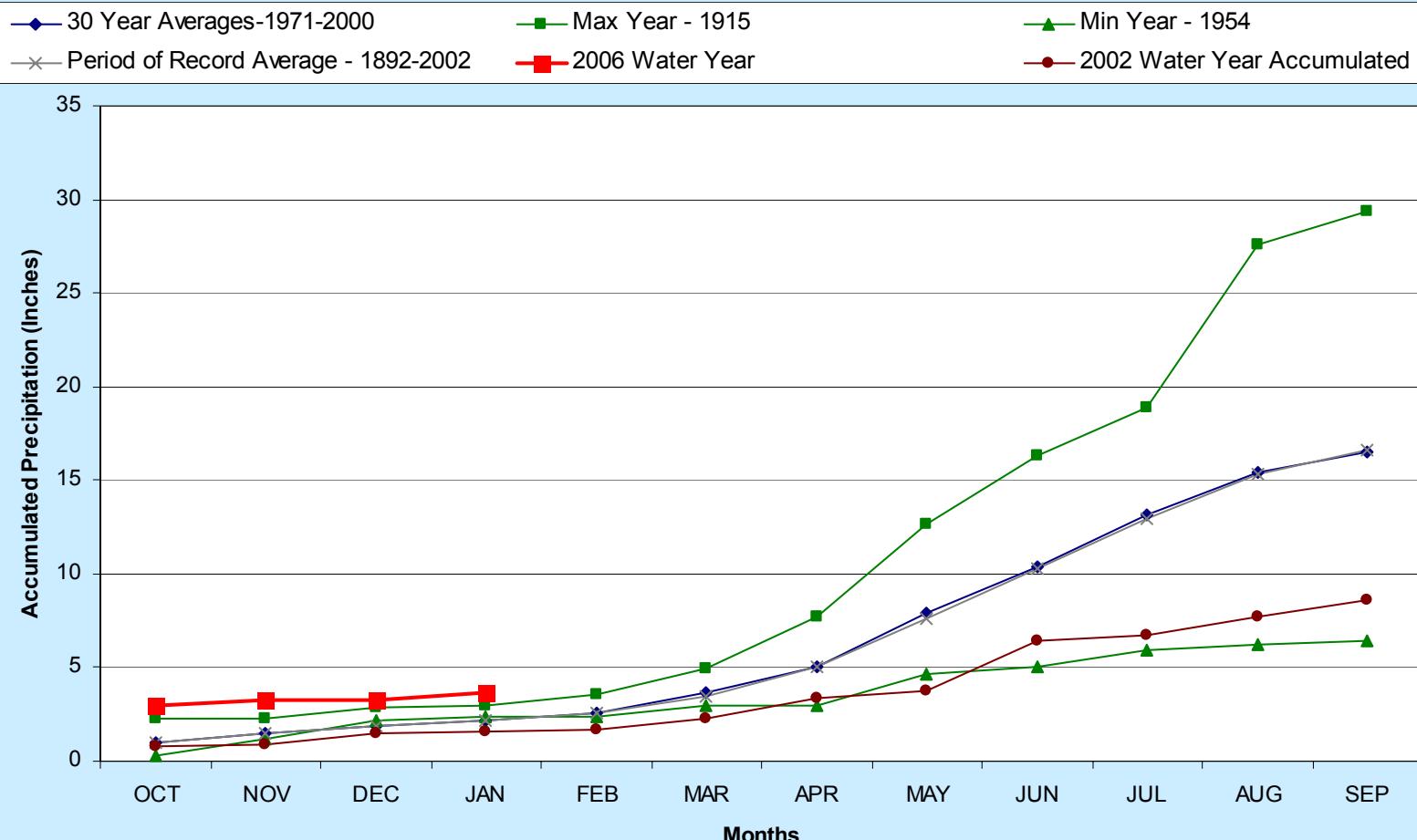
## Cheyenne Wells 2006 Water Year

◆ 30 Year Averages-1971-2000      ■ Max Year - 1909      ▲ Min Year - 1956  
—×— Period of Record Average - 1971 - 2002      —■— 2006 Water Year      ●—●— 2002 Water Year Accumulated



# Burlington 2006 Water Year

## Burlington 2006 Water Year

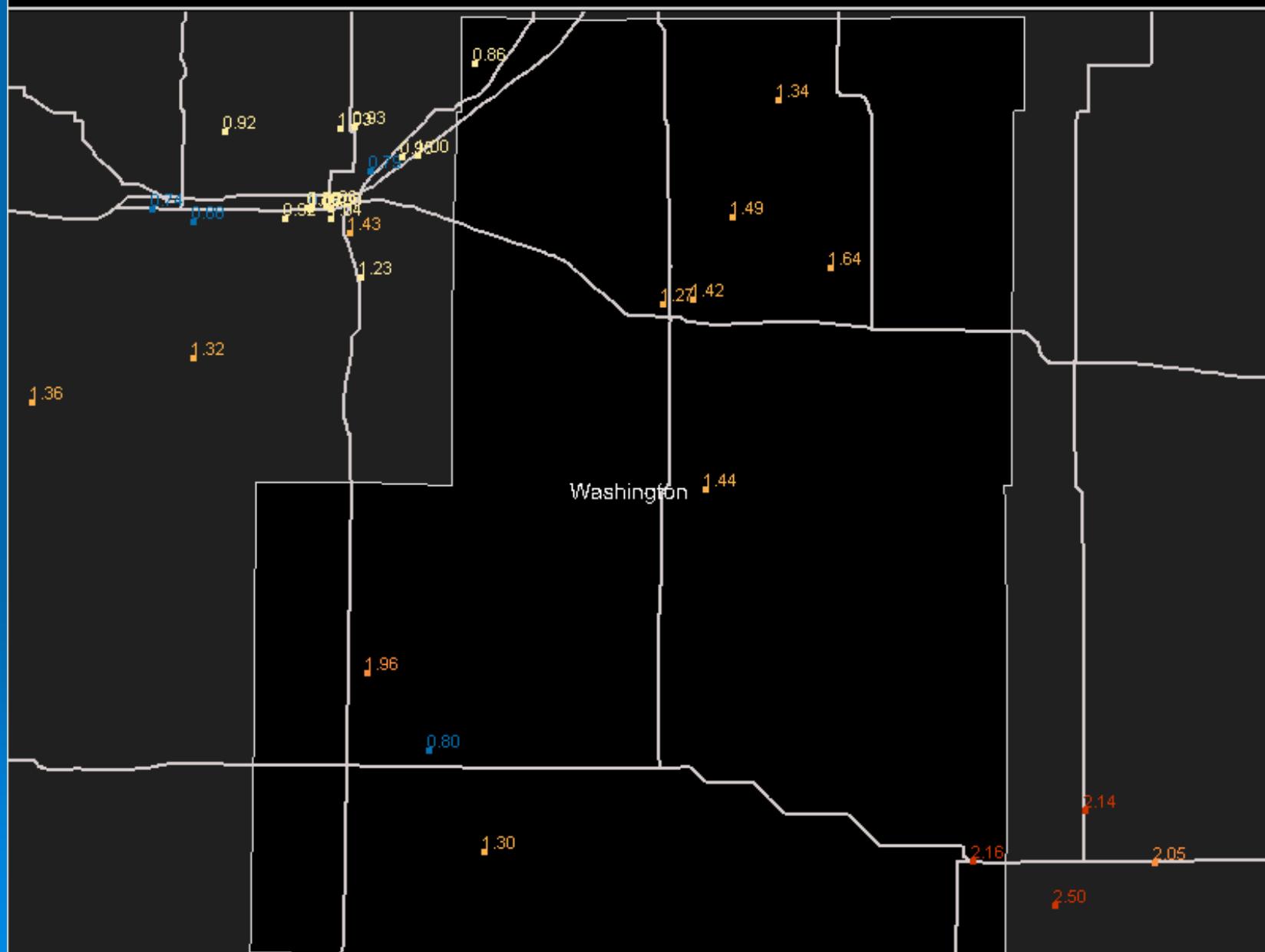


# Washington County 10/10/05

Daily Precipitation (inches x.xx), for the 24 hour period ending ~7:00 am

Washington County, Colorado 10/10/2005

0.0 Trace 0.01 - 0.42 0.42 - 0.83 0.83 - 1.25 1.25 - 1.67 1.67 - 2.08 2.08 - 2.50

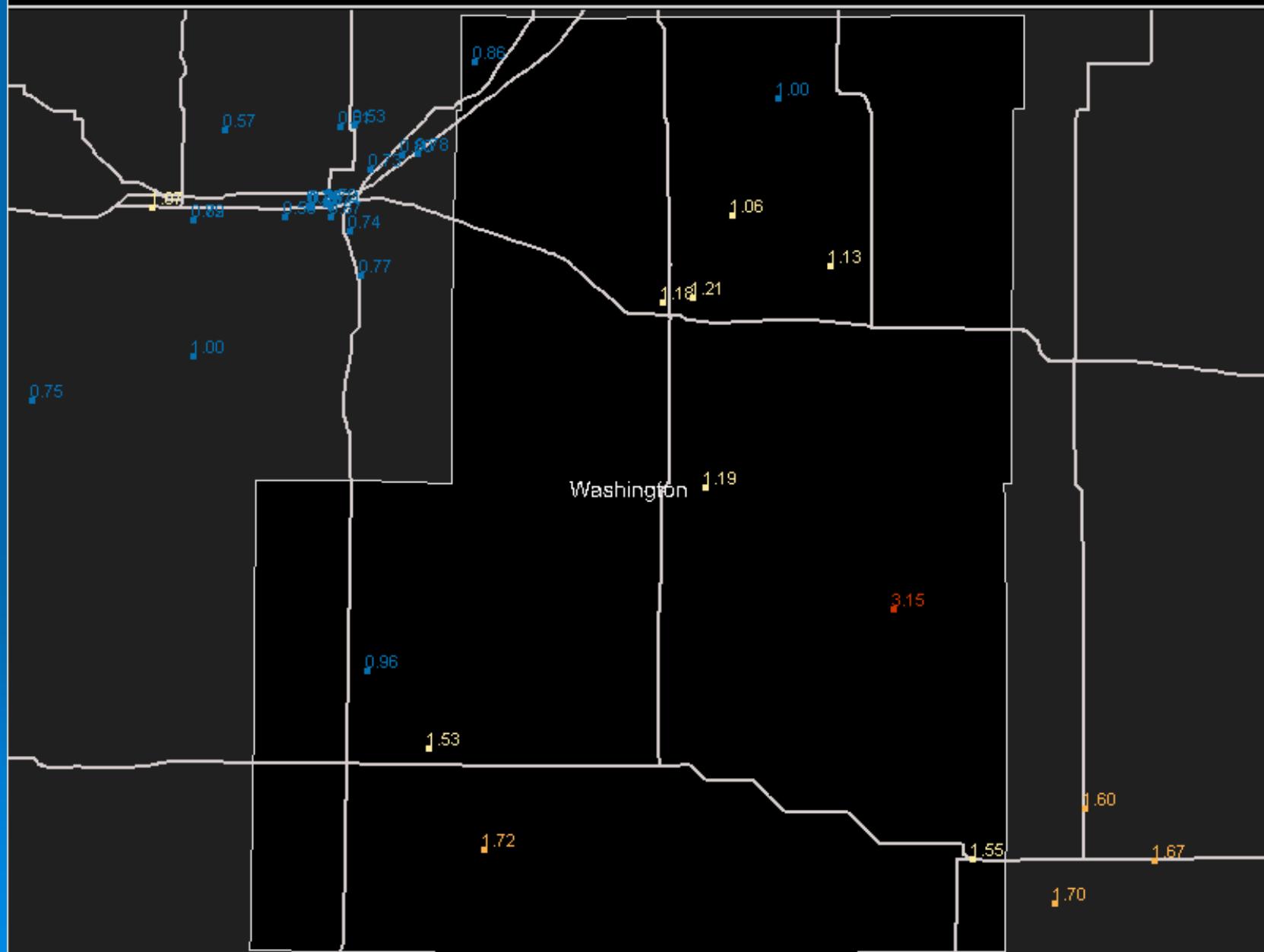


# Washington County 10/11/05

Daily Precipitation (inches x.xx), for the 24 hour period ending ~7:00 am

Washington County, Colorado 10/11/2005

0.0 Trace 0.01 - 0.53 0.53 - 1.05 1.05 - 1.58 1.58 - 2.10 2.10 - 2.63 2.63 - 3.15



**cocorahs**

Community Collaborative Rain, Hail & Snow Network

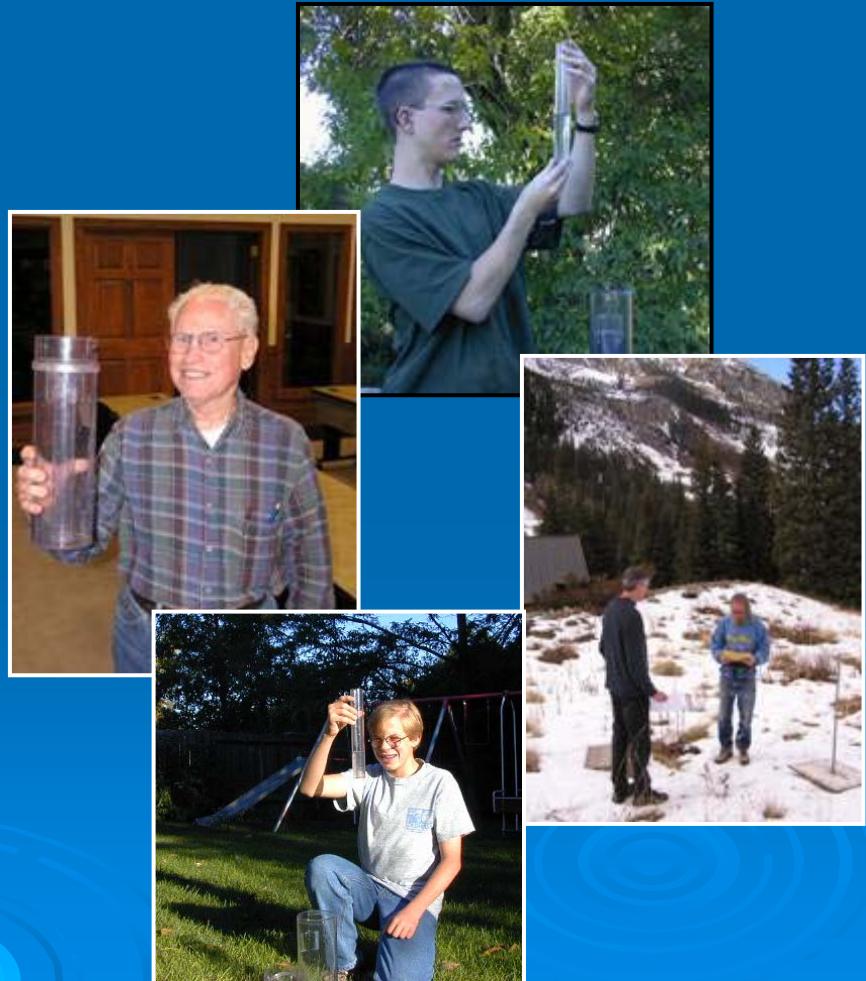


*Precipitation – We could sure  
use more data!*



# What is CoCoRaHS?

CoCoRaHS is a unique, non-profit community based network of volunteers of all ages and backgrounds working together to measure and map precipitation (rain, hail and snow).



“By using low-cost measurement tools, stressing training and education, and utilizing an interactive Web-site, our aim is to provide the highest quality data for natural resource, education and research applications.”

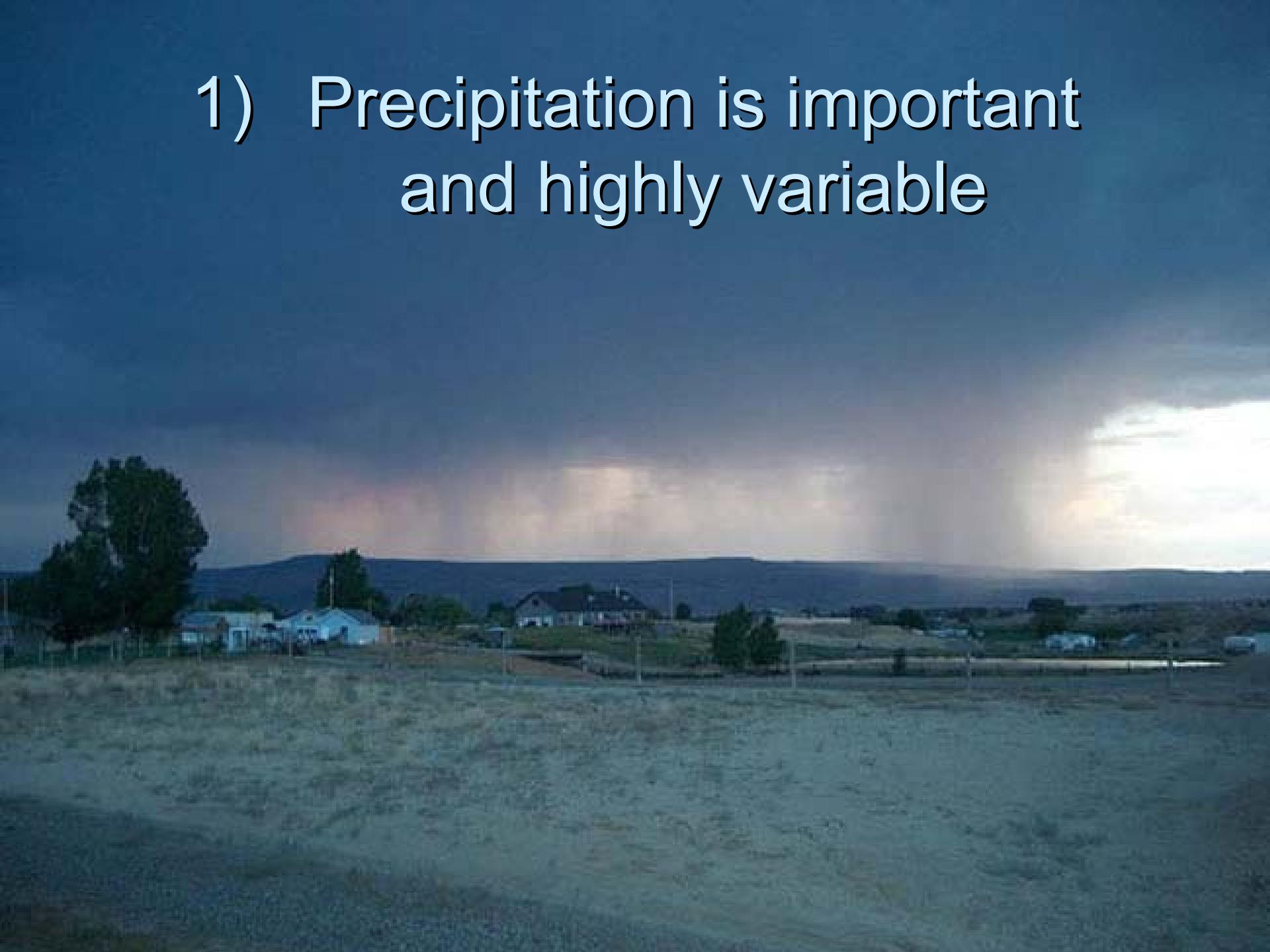


The screenshot shows the homepage of the Community Collaborative Rain, Hail & Snow Network (CoCoRaHS) website. The top navigation bar includes links for Home, States, View Data, and Maps, along with My Data Entry and Login. A sidebar on the left lists Main Menu items: Home, Join CoCoRaHS, Contact Us, and In the Spotlight. The main content area features a map of the United States where several states are highlighted in green or blue. A callout box on the right asks, "Would you like your state to be a part of the CoCoRaHS Network? Contact us at [info@cocorahs.org](mailto:info@cocorahs.org)." At the bottom, a welcome message from CoCoRaHS is displayed, followed by a small image of a person holding a rain gauge.

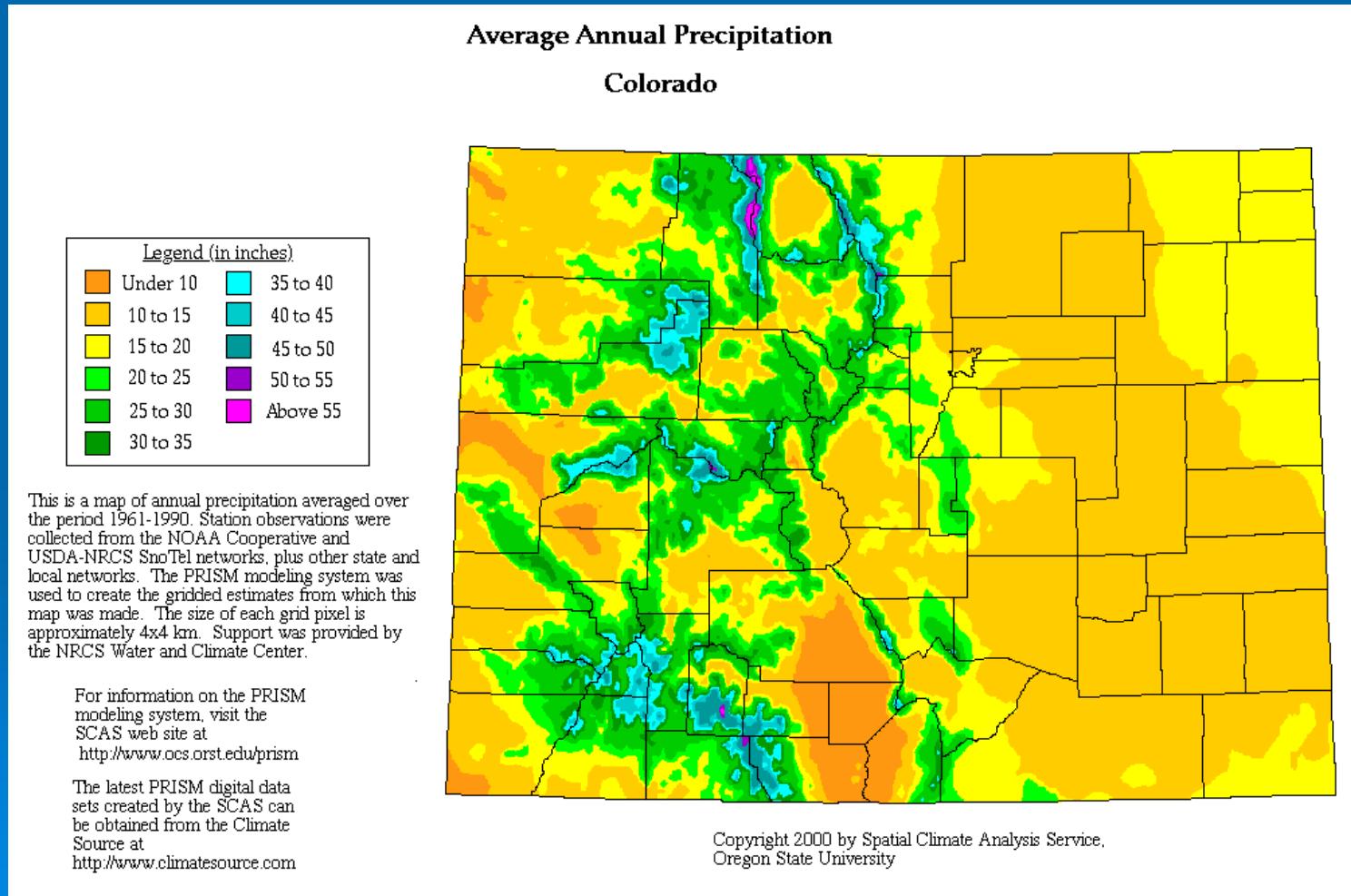
# Some reasons for measuring



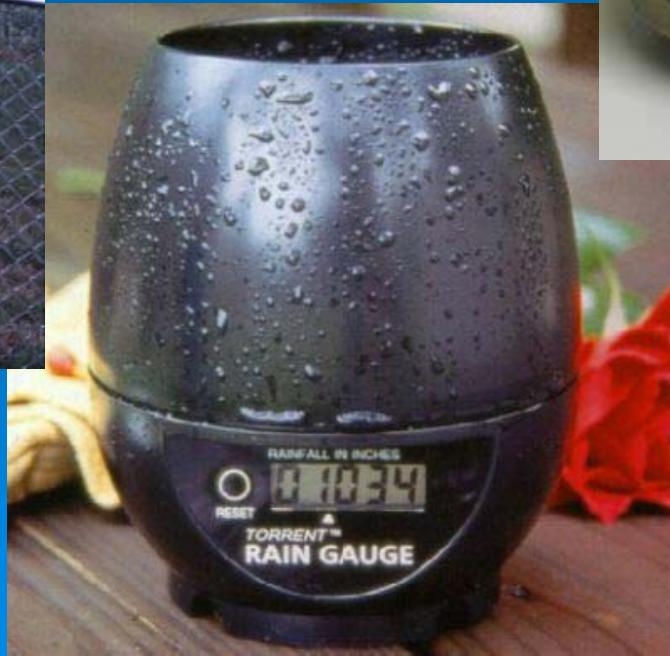
1) Precipitation is important  
and highly variable



## 2) Existing weather stations are too far apart



# 3) Electronic measurements of precipitation are unsatisfactory



# 4) Storm reports can save lives



**Wednesday**

**FORT COLLINS COLORADOAN**

**City death toll at 5; damage in millions**

**STORM TOLL**

Deaths - 5 confirmed  
Injuries - 40  
Missing - 16  
Rescued - 160

Damages - Tens of millions of dollars at Colorado State University. \$1.5 million to \$2 million to city roads and bridges; \$1 million to city parks and trails; no estimate for private property.

Source: Emergency Offices  
All information as of 1 a.m. today

**July 30th 1997**

**CSU's book losses speak volumes**

**Rainfall breaks 20-year record**

A newspaper clipping from the Fort Collins Coloradoan dated Wednesday, July 30, 1997. The headline reads "City death toll at 5; damage in millions". The article discusses the storm toll, including 5 deaths, 40 injuries, 16 missing, and 160 rescued. It also details the damages, particularly at Colorado State University, mentioning \$1.5 million to \$2 million for city roads and bridges, and \$1 million for city parks and trails. The newspaper also includes a sidebar about CSU's book losses and rainfall breaking a 20-year record.



# What's Involved?

 COMMUNITY COLLABORATIVE RAIN, HAIL, AND SNOW NETWORK  
[www.cocorahs.org](http://www.cocorahs.org)

## Volunteer Application Form

Name: \_\_\_\_\_ Date: \_\_\_\_\_  
Address: \_\_\_\_\_  
City: \_\_\_\_\_ PO Box: \_\_\_\_\_  
State: \_\_\_\_\_ Zip: \_\_\_\_\_ County: \_\_\_\_\_  
Home Phone: ( ) \_\_\_\_\_ Daytime Phone: ( ) \_\_\_\_\_  
E-mail Address: \_\_\_\_\_ Daily Internet Access: Yes / No  
Give a brief description of your map location (Latitude/Longitude if available): \_\_\_\_\_

Nearest cross streets/roads: \_\_\_\_\_  
(Please use back of application to draw a map of your site, if located in a rural area – thanks!)  
If 18 years or younger (minor or adult), please fill out the shaded section below:

Age: \_\_\_\_\_ Parent or Guardian Name: \_\_\_\_\_  
Grade: \_\_\_\_\_ What school do you attend: \_\_\_\_\_

How did you find out about this project?  
In order to participate in this project, you are highly encouraged to attend a special 90-minute training session on measuring rain and hail. It is more fun than it sounds. Dates, times, and locations will be listed.

Volunteers may qualify for a free rain gauge provided by CoCo RaHS sponsors.  
I would like to:  Donate \$25 for a rain gauge and other supplies to help offset supply costs!  
 Receive Complimentary Gauge  
 Use your own gauge. Describe: \_\_\_\_\_

(Rain gauge must be same type as CoCoRaHS gauge)

Rain gauge will be read and emptied daily at:  
 7:00 a.m. (highly recommended)  6:00 a.m.  8:00 a.m.  Other time: \_\_\_\_\_

It is important to the project that your rain gauge is read and emptied at the same time each day. However, the CoCo RaHS staff does realize that summer is a time for vacations. We do not ask that you sacrifice your entire summer for the sake of the project, but please report when you are able.

If you or a family member would like to volunteer for additional project duties, check here:  
 YES, I would like to help — Call me!

Please give the names and ages of others who will help you take rain & hail measurements:  
Name/Age: \_\_\_\_\_ Name/Age: \_\_\_\_\_

I would prefer to:  Train On-line  Attend a Training Session  Walk-in Training  
Please return this form to:  
Local CoCo RaHS Coordinator \_\_\_\_\_

Or return to:  
CoCoRaHS – Colorado Climate Center  
Department of Atmospheric Sciences  
Colorado State University • Fort Collins, CO 80523-1371

**For Staff Use Only**

Station Name: _____	Longitude: _____
Station Number: _____	Latitude: _____
Date Trained: _____ Date Station Num. Issued: _____	
Date Received/Shipped Gauge: _____	
Date Contacted: _____	

# How to sign up?

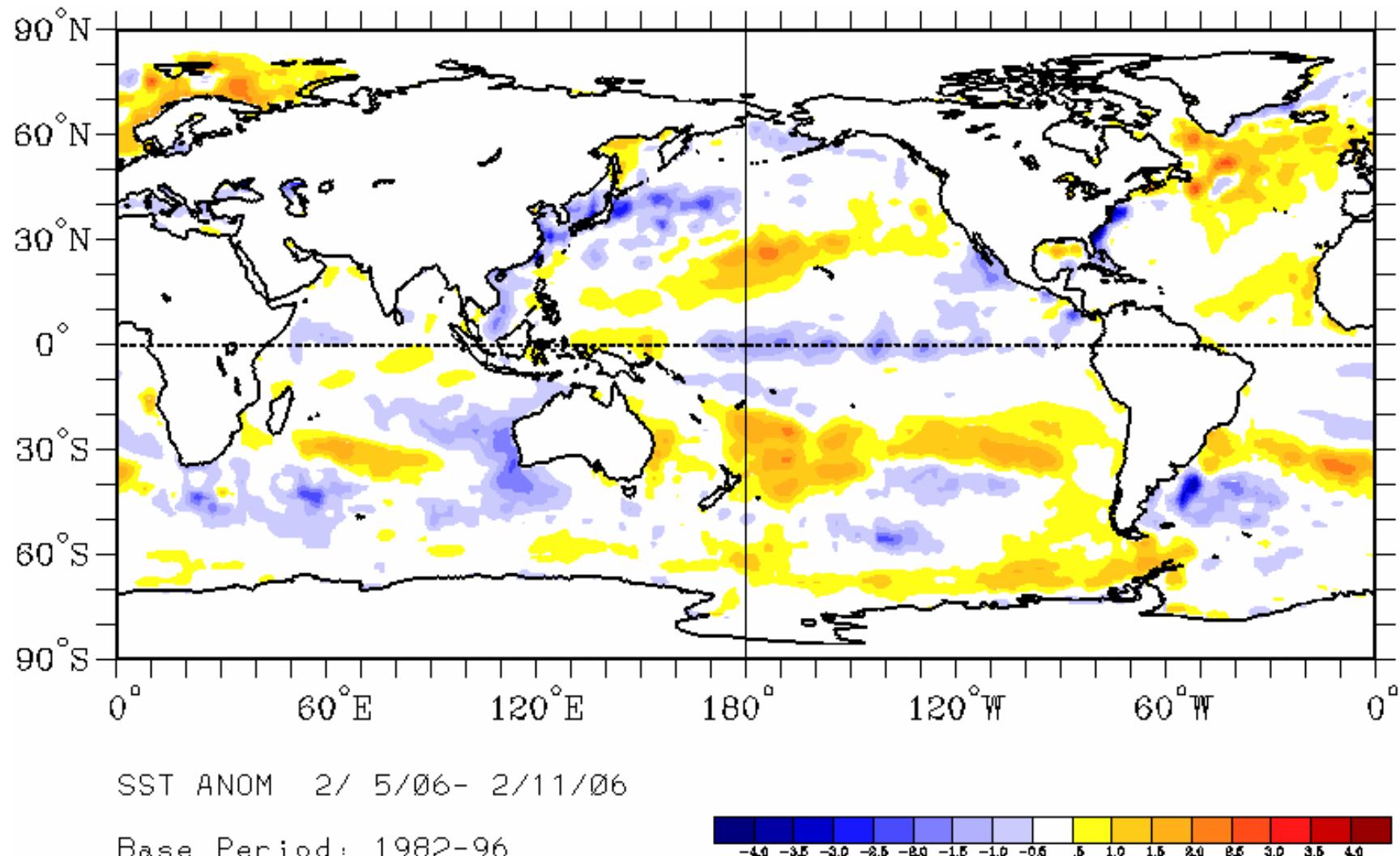
- See Me after talk  
or
- Fill out application  
at CoCoRaHS  
display  
or
- Fill out “Join Us”  
form online at  
[www.cocorahs.org](http://www.cocorahs.org)



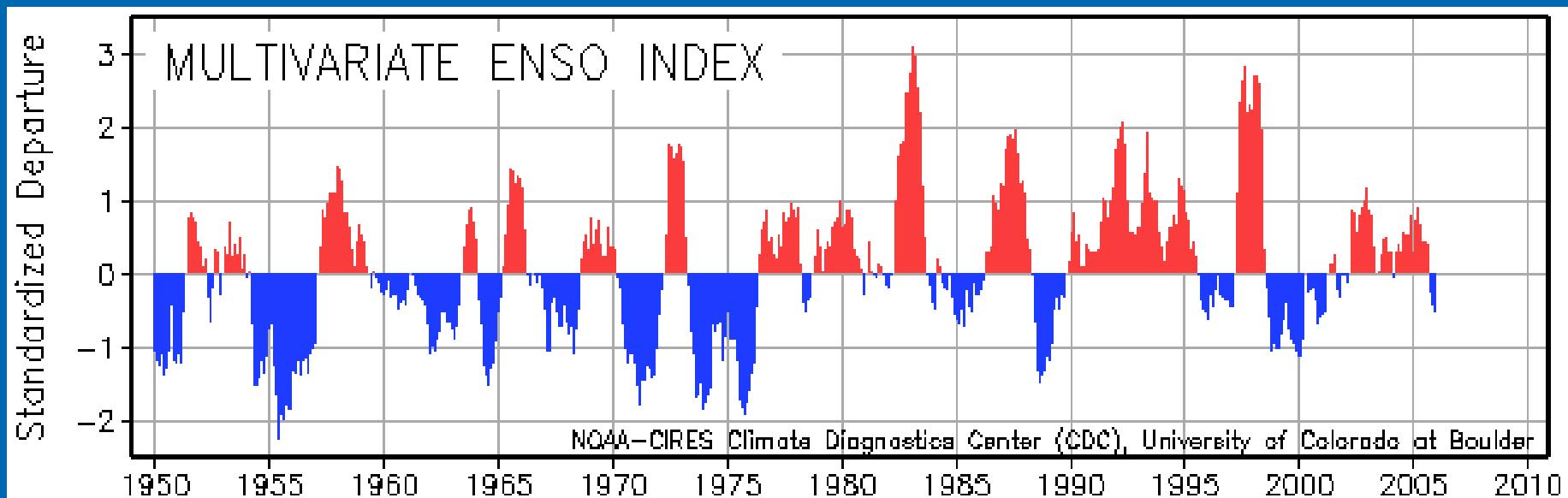
# Finally, what's ahead for this Spring and Summer?



# Sea Surface Temperature Anomaly



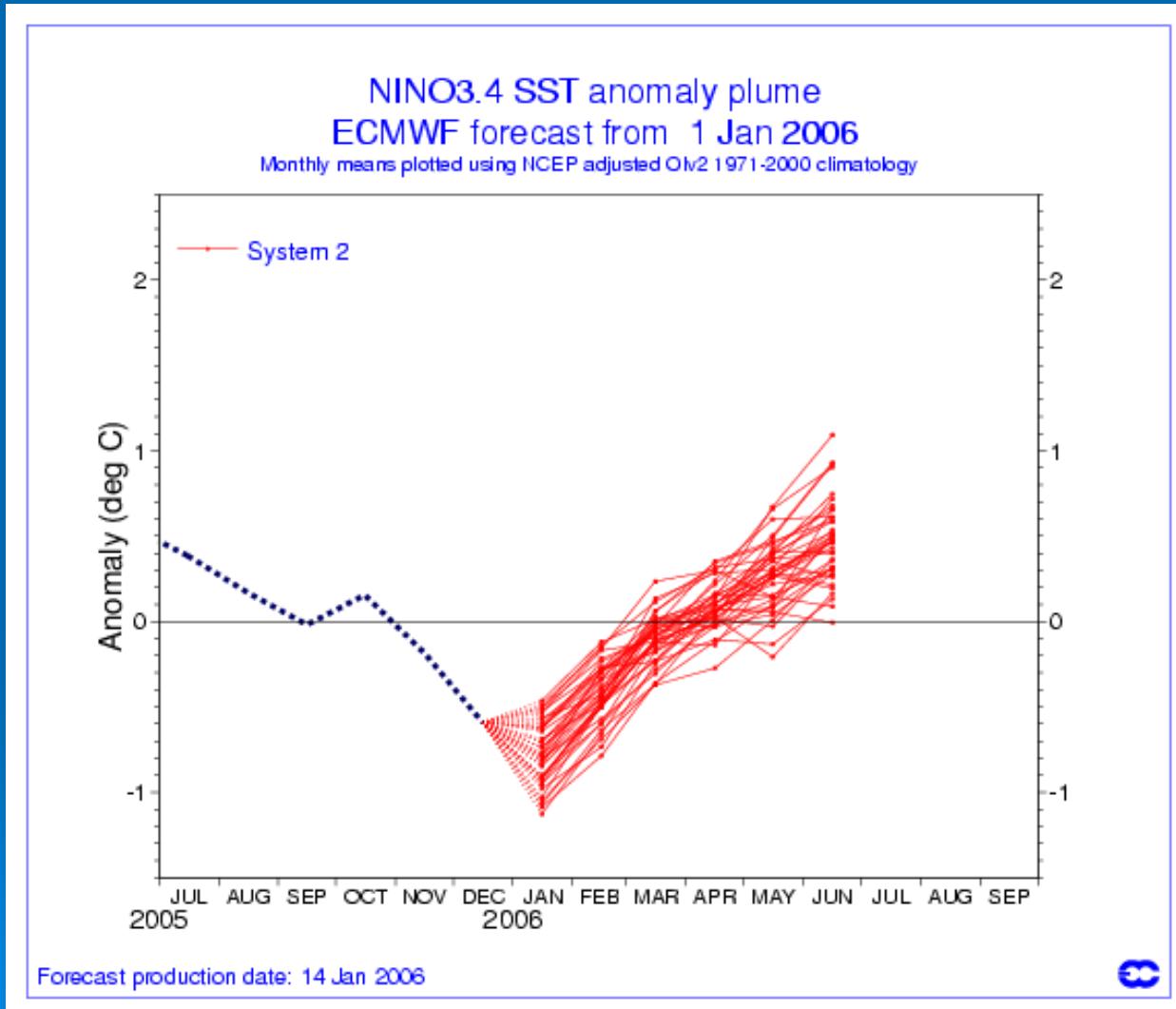
# Multivariate ENSO Index (MEI)



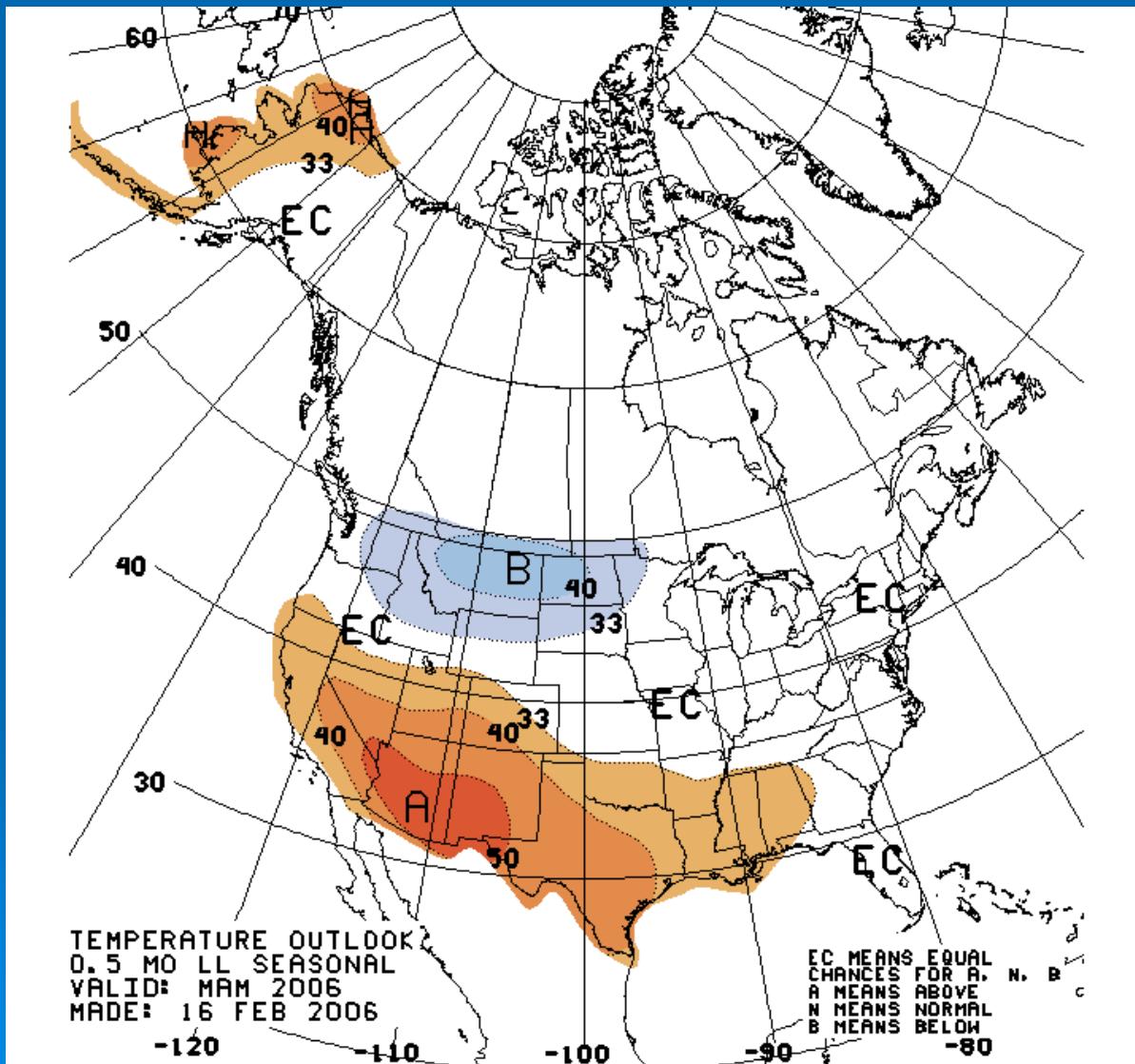
Last update: February 6, 2006

<http://www.cdc.noaa.gov/people/klaus.wolter/MEI/>

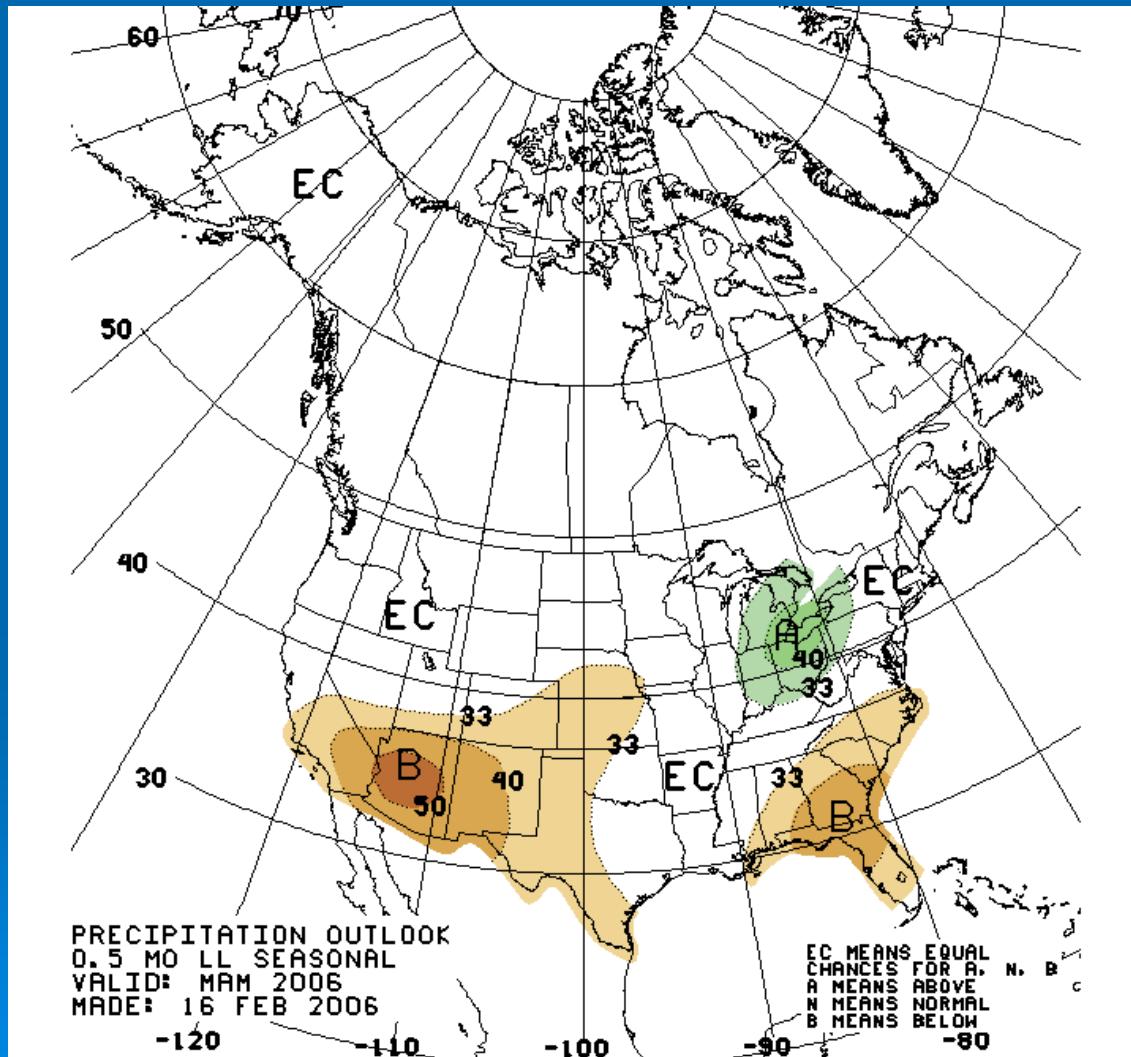
# El Nino Forecast



# Temperature Mar-May 2006



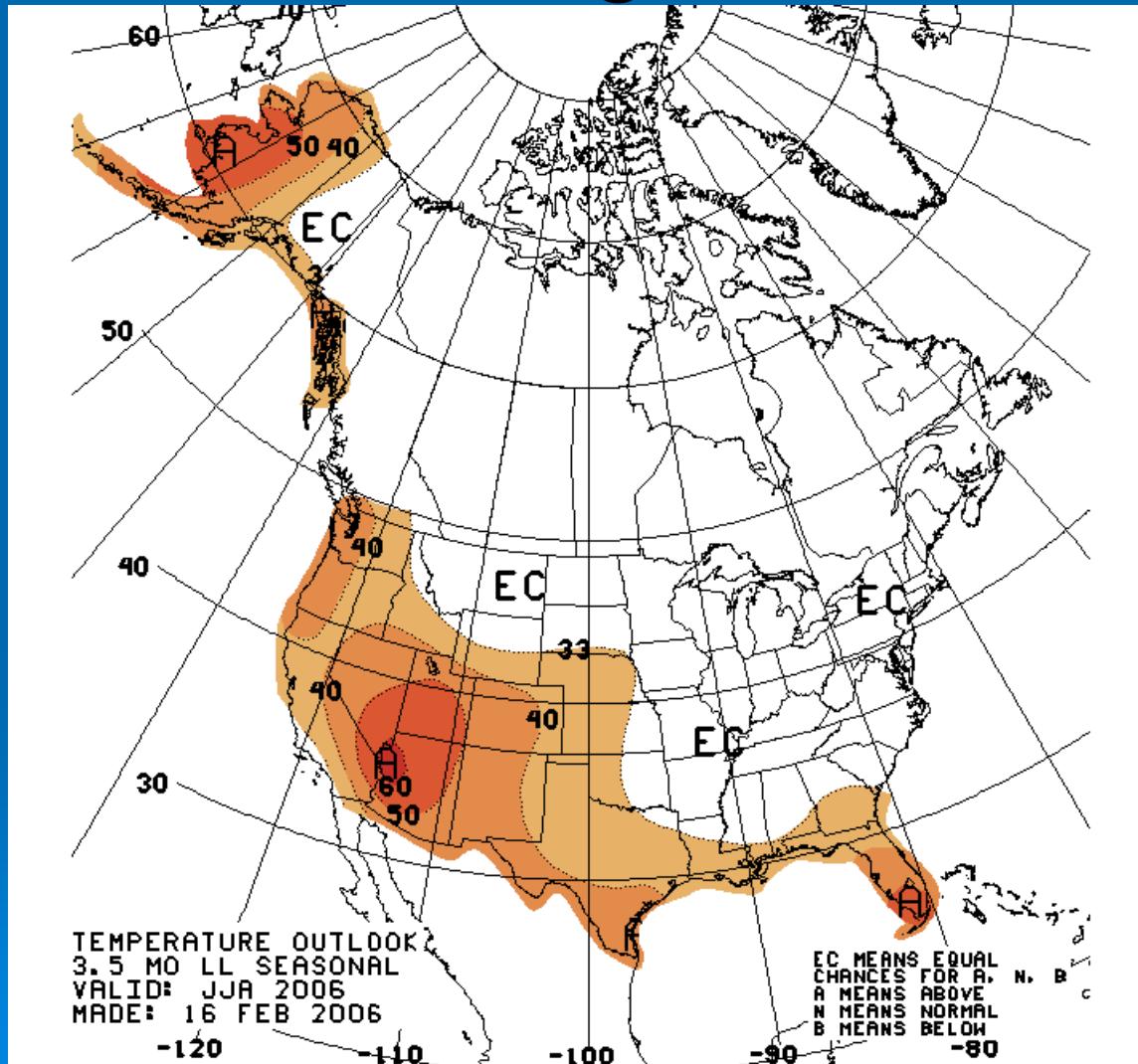
# Precipitation Mar-May 2006



From the Colorado Prediction Center

[http://www.cpc.ncep.noaa.gov/products/predictions/multi\\_season/13\\_seasonal\\_outlooks/color/churchill.html](http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html)

# Temperature Jun-Aug 2006

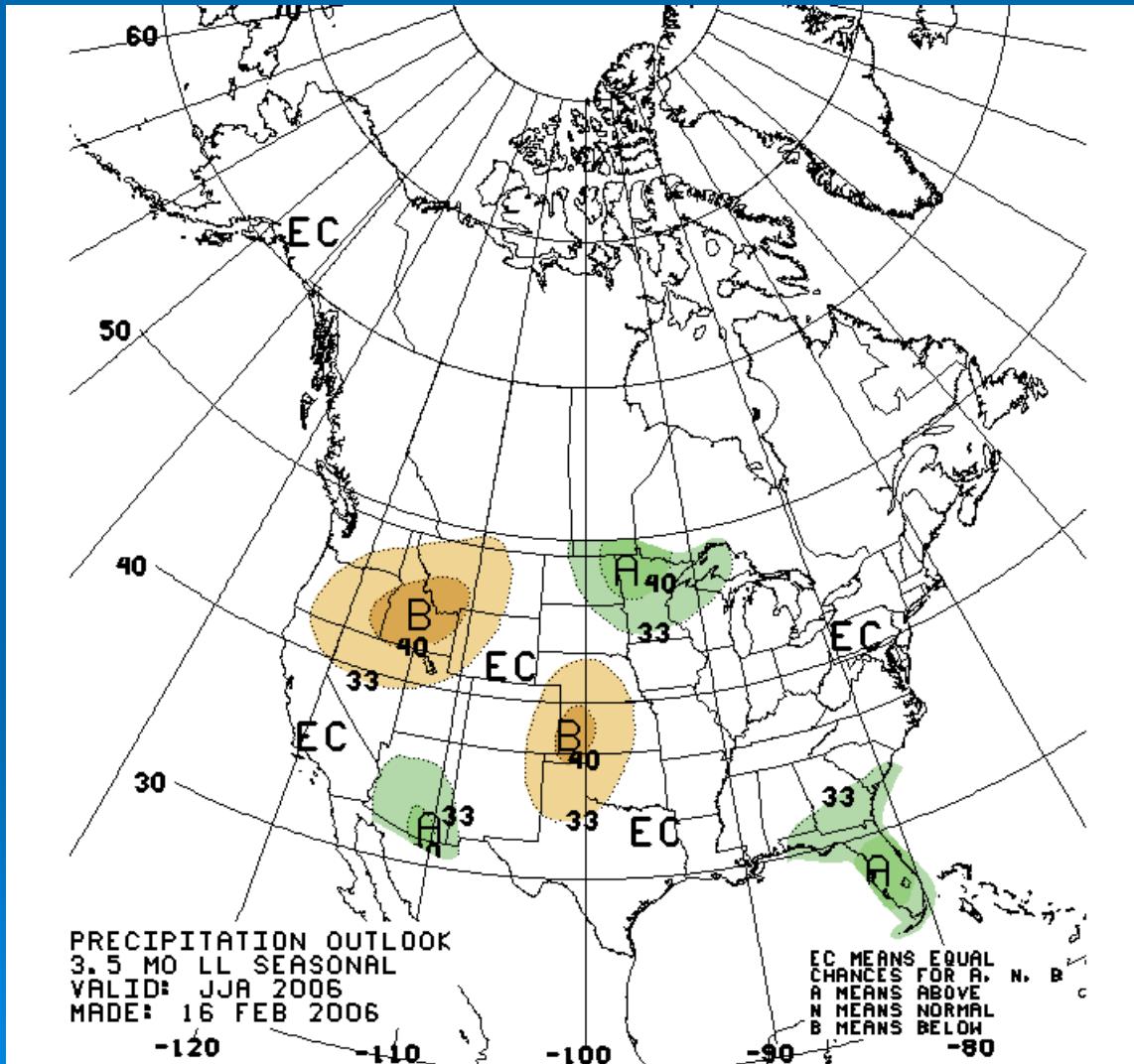


From the Colorado Prediction Center

[http://www.cpc.ncep.noaa.gov/products/predictions/multi\\_season/13\\_seasonal\\_outlooks/color/churchill.html](http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html)

# Precipitation

## Jun-Aug 2006



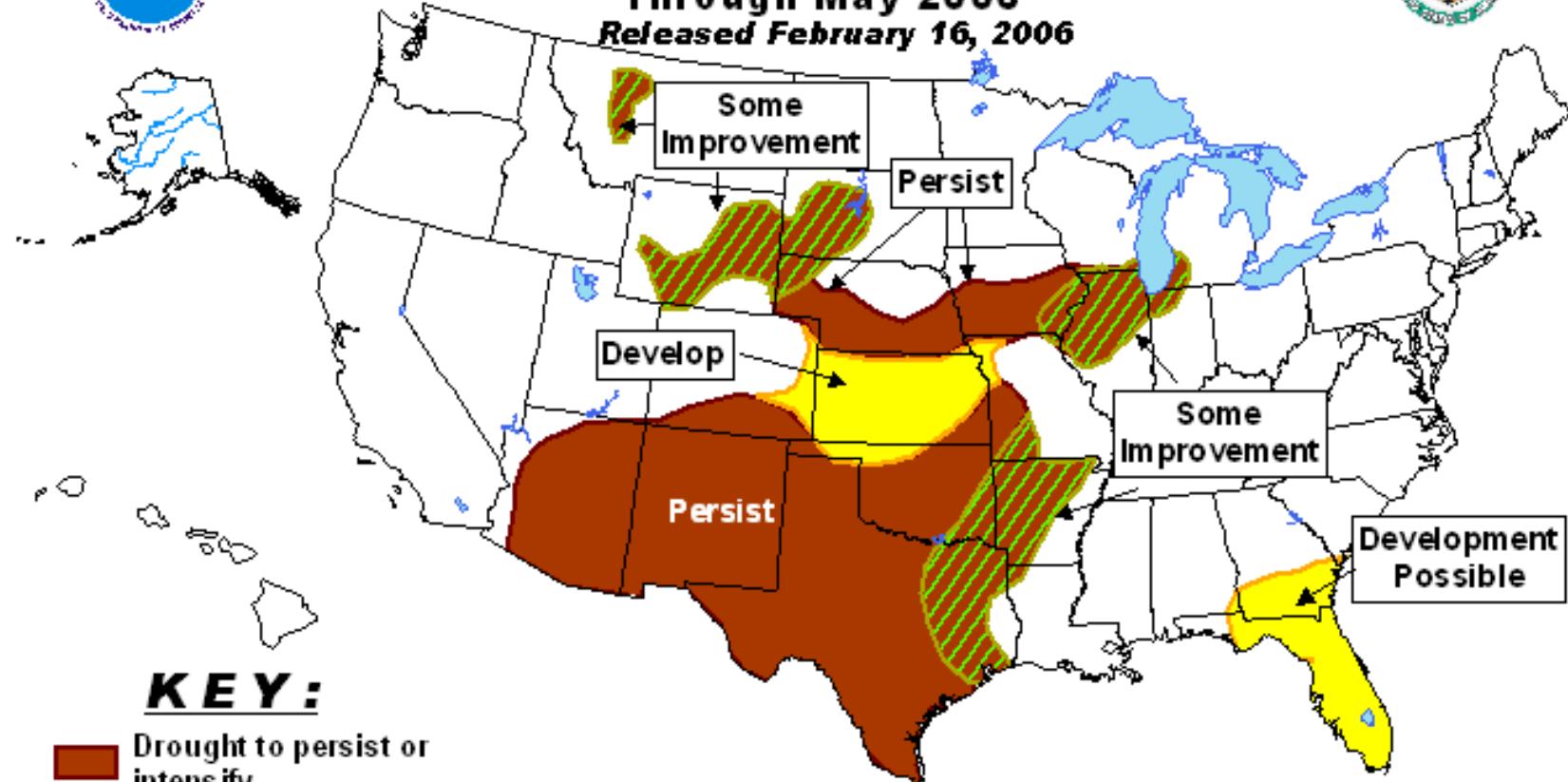
From the Colorado Prediction Center

[http://www.cpc.ncep.noaa.gov/products/predictions/multi\\_season/13\\_seasonal\\_outlooks/color/churchill.html](http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html)



# U.S. Seasonal Drought Outlook

Through May 2006  
Released February 16, 2006

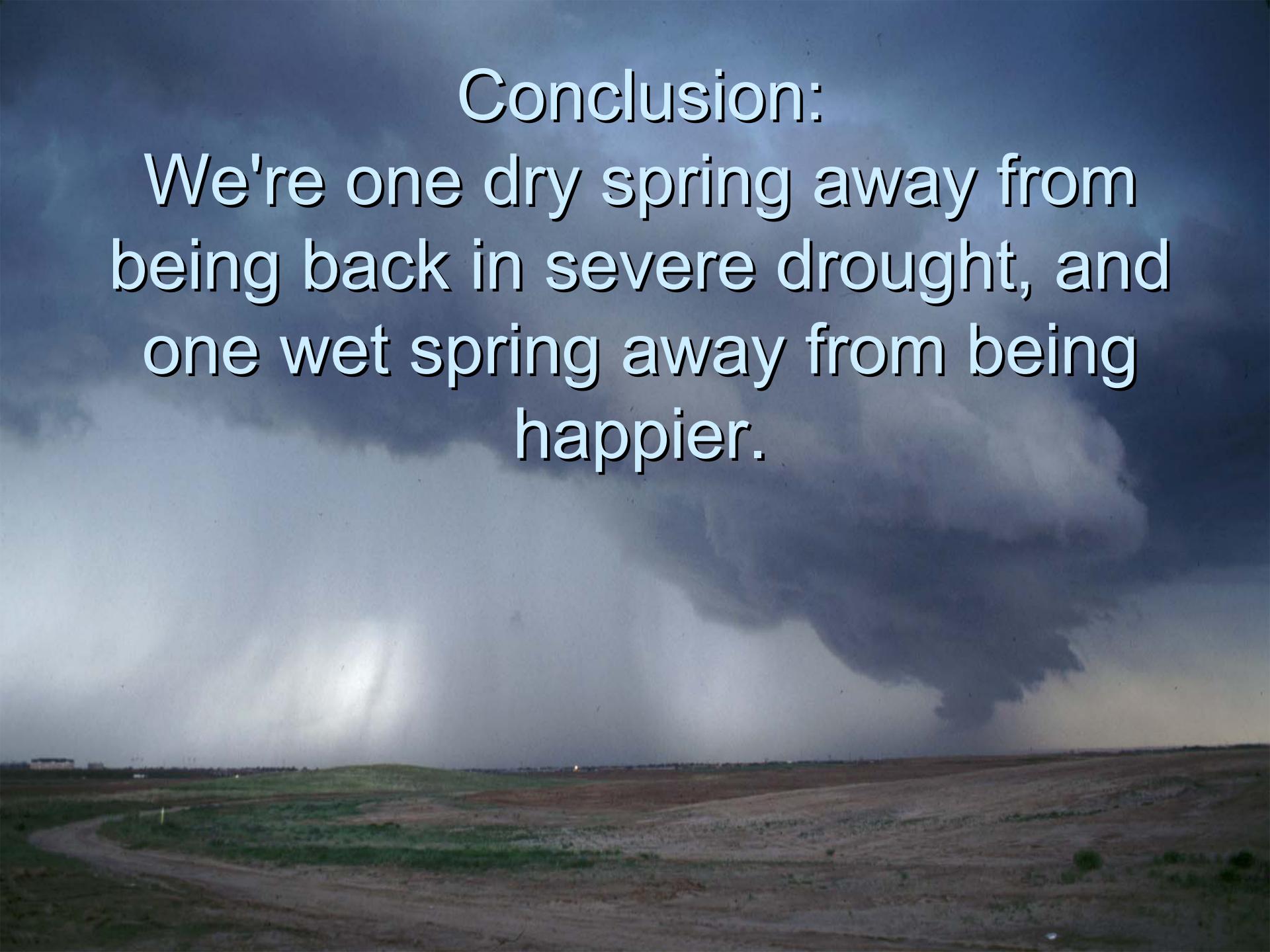


## KEY:

- Drought to persist or intensify
- Drought ongoing, some improvement
- Drought likely to improve, impacts ease
- Drought development likely

Depicts general, large-scale trends based on subjectively derived probabilities guided by numerous indicators, including short- and long-range statistical and dynamical forecasts. Short-term events -- such as individual storms -- cannot be accurately forecast more than a few days in advance, so use caution if using this outlook for applications -- such as crops -- that can be affected by such events. "Ongoing" drought areas are approximated from the Drought Monitor (D1 to D4). For weekly drought updates, see the latest Drought Monitor map and text. NOTE: the green improvement areas imply at least a 1-category improvement in the Drought Monitor intensity levels, but do not necessarily imply drought elimination.

Conclusion:  
We're one dry spring away from  
being back in severe drought, and  
one wet spring away from being  
happier.

A dramatic photograph of a large, dark, swirling tornado in a field. The tornado is visible against a bright, overexposed sky, creating a strong silhouette effect. The ground in the foreground is a mix of green grass and brown, dry soil, suggesting a rural or agricultural area. The overall mood is somber and powerful, reflecting the message of the text about the fragility of weather patterns.

A photograph of a vast field of golden wheat under a clear blue sky. The wheat stalks are ripe and swaying slightly. In the distance, there are some trees and a few power lines. The overall scene is a typical rural landscape.

But in this land, any drought recovery is temporary.

15-18" of moisture is a lot better than nothing, but it doesn't leave you any margin.

# Colorado Climate Center

## Colorado State University

- Data and Power Point Presentations available for downloading
- <http://ccc.atmos.colostate.edu>  
click on “Drought”  
then click on “Presentations”

